

PACIFIC ISLANDS GLOBAL CLIMATE OBSERVING SYSTEM (PI-GCOS) PROGRAM

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1. INTRODUCTION

The U.S. GCOS program based at NOAA's National Climatic Data Center supports the international GCOS effort. This support fits in with a proactive process approach for GCOS implementation planning with the goal of obtaining a sustainable and robust GCOS observing network for international atmospheric, oceanographic, and terrestrial climate observing. Actions have been taken and plans are in place regarding international, regional, bi-lateral, and U.S. national level GCOS activities. Performance measures are being used to determine where and how best to fill gaps in GCOS surface and upper air network global coverage.

2. BACKGROUND

Meteorological surface-based networks, utilized for climate purposes, make observations of important climate factors, atmospheric profiles, and pollutant emissions, aerosols, and ozone. These surface-based networks are intended to provide the basic observational set needed to define the status and trends in climate of the world, and also to calibrate and validate satellite-based observations. Although hundreds of millions of dollars are spent each year on developing and operating space-based observation systems, surface-based meteorological networks are "under reporting" their observations in many parts of the developing world. This is because of declining economies and the lack of understanding of how these observations contribute to the global effort to monitor climate. Consequently, these networks are operating substantially below their design standards and important observations are either not being made, or are not being communicated to users. Workshops are being conducted to define GCOS deficiencies and, during the next several years, more detailed activities to improve the networks will be identified. The implementation of a GCOS Cooperation Mechanism (GCM) was begun in 2004 as a way of identifying resources (both financial and in-kind) to aid in improving the operation of GCOS monitoring stations in developing nations. The GCM is being used to implement an overall global GCOS Improvement Program; support, both in funds and in-

kind support, have been provided, in addition to the U.S. by Australia, New Zealand, South Africa, Spain, and the United Kingdom. International support for GCOS has been growing over the past couple of years and a second formal meeting of the GCM Donor Board was held in Montreal in November 2005.

At its most recent summit in Gleneagles, Scotland, the G8 reiterated its commitment made in 2003 in Evian, France, to strengthen international cooperation on global Earth observations. In their 2005 statement the G-8 said:

"We will continue to exercise leadership in this area, and welcome the adoption of the 10-year implementation plan for development of the Global Earth Observation System of Systems (GEOSS) at the Third Earth Observations Summit which took place in Brussels in February this year. We will: (a) move forward in the national implementation of GEOSS in our member states; (b) support efforts to help developing countries and regions obtain full benefit from GEOSS, including from the Global Climate Observing System (GCOS) such as placement of observational systems to fill data gaps, developing of in-country and regional capacity for analysing and interpreting observational data, and development of decision-support systems and tools relevant to local needs; (c) in particular, work to strengthen the existing climate institutions in Africa, through GCOS, with a view to developing fully operational regional climate centres in Africa."

As such, NOAA's U.S. GCOS Program Office, which represents the U.S. on the GCOS Cooperation Board, has committed to leading the way for facilitating improvements in the management and operation of GCOS and GCOS-related atmospheric networks. The U.S. GCOS Program Office has taken leadership, working with our partners at the WMO, in further GCOS improvements. This work began in Fiscal Year (FY) 2003 and plans are for continued efforts in this area for the foreseeable future. However, improvements in the various international GCOS networks cannot be done by NOAA alone, and are dependent on matching contributions from other developed nations via the GCM to aid in leveraging and implementing improvements to GCOS networks, and sustaining them. The program reflects a broad-based approach that looks at supporting observing and data management activities at the international, regional, and bi-lateral levels. In addition, support for Pacific Islands Ocean and Climate observing regional coordinators in Fiji and Samoa to aid in coordinating these observing activities among developing countries in the region has been a great boost towards capacity building in that critical region.

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The support for developing nations has primarily been for retrofitting surface and upper air observing stations that have up-to-now been silent but yet are key to global climate monitoring activities. Countries that have received new equipment and expendables over the past three years include: Argentina, Armenia, Congo, Cook Islands, Costa Rica, Ecuador, Ivory Coast, Kenya, Maldives, Namibia, the Philippines, and Zimbabwe. In addition to equipment, in cooperation with the U.S. State Department, a number of workshops for enhancing climate change monitoring in support of the Intergovernmental Panel on Climate Change (IPCC) have or are being staged in South Africa, southern South America, northern South America and Central America, Southwest Asia, and Southern Asia. These are all hands-on workshops involving seminars and hands-on work with data from the various countries in attendance. In addition, the State Department has been instrumental in aiding in the establishment of regional GCOS maintenance facilities which have been established in the Pacific and the Caribbean. Another one is being planned for Southern and Eastern Africa in order to further the sustainability of the GCOS network in the developing nations of that region.

3. PERFORMANCE MEASURES

In general, GCOS performance measures used by NOAA in managing its international support are intended to gradually increase the quality and quantity of data from the GCOS Surface Network (GSN) and GCOS Upper Air Network (GUAN) over the next several years. The performance measures focus on observing system improvements in developing nations in Africa, South America, and the Pacific Islands; improved GCOS data from these climatically vulnerable areas will assist researchers, policymakers, educators, and others in decision making and other critical applications.

For the GSN, the performance measure is the percent explained variance in mean annual temperature in the developing world. The long-term goal is 90% explained variance with a network of 75 stations. This will be accomplished by deploying new observing stations that meet the same stringent requirements as those in the U.S. Climate Reference Network.

For the GUAN, the long-term objective is to increase the percent of GUAN sites in the developing world that meet GCOS reporting requirements (i.e., two soundings per day for 25 days in the month, each sounding with temperature/wind data up to 5 hPa and humidity data up to the tropopause). This will be accomplished by modernizing 75 existing GUAN stations. The long-term goal is to have 90% of the GUAN stations in the developing world meeting GCOS requirements.

4. BACKGROUND OF THE U.S. GCOS PROGRAM

The U.S. has been involved with GCOS since its inception. Since 1992, a considerable amount of work

has been done by various federal agencies. In particular, federal agencies have supported the international GCOS Steering Committee, and the work of the GCOS data, space, and science panels, as they have engaged in planning GCOS, defining its requirements, and contributing parts of the initial system. NOAA's National Climatic Data Center (NCDC) in Asheville, North Carolina, supports a number of GCOS data management activities and hosts the U.S. GCOS Program Office based in Silver Spring, Maryland.

The primary focus of this office is to coordinate the development of a national GCOS program that involves all U.S. federal agencies with a role in climate observing and monitoring. As part of this effort, the U.S. national program has taken a three-tiered approach to fostering the GCOS program. This approach involves providing support: (1) Internationally to improve and enhance monitoring stations in developing nations that require assistance as identified by the international GCOS Atmospheric Observations Panel for Climate; (2) regionally for workshops and projects such as those in the Pacific Ocean region for ensuring a robust and sustainable GCOS observing program; and (3) on a bi-lateral basis with nations that have entered into agreements with the U.S. on improving climate observing activities. The U.S. GCOS Program Office is currently involved in funding bi-lateral climate projects with Australia, China, New Zealand, and South Africa.

Like other developed nations, the U.S. was required to submit a report on the status of its systematic observations for climate. The full report is available at the U.S. National GCOS home page at http://www.eis.noaa.gov/gcos/soc_long.pdf.

5. SUPPORT ACTIVITIES FOR GCOS

In addition to the requirements for national reports on systematic observations, the United Nations Framework Convention on Climate Change (UNFCCC) at its 1999 meeting invited the GCOS Secretariat to continue to assist with and facilitate the establishment of an appropriate intergovernmental process that would identify potential improvements in the global observing system for climate and set priorities for acting on those improvements. As such, the U.S. GCOS program has been one of the leaders in this effort.

The U.S. continues to be an active participant in and large support of the international GCOS program in a number of areas. These areas of support can be characterized in three categories: (1) Global; (2) regional; and (3) bi-lateral.

5.1 Global Support

The global support represents the overall U.S. Government's support of GCOS. In May 2002, the U.S. State Department contributed \$600K (US) in funding to the GCOS Secretariat in order to conduct the second adequacy study of GCOS on a global basis. This

adequacy study was called for by the UNFCCC and is a joint GCOS/IPCC effort. This was intended to produce an adequacy report based on among other things the analysis of GCOS national reports in order to focus attention on critical gaps in the overall global climate observing in order for resources to be better directed. Published in April, 2003, *The Second Report on the Adequacy of GCOS* provides a detailed assessment on the gaps in GCOS that provides solid scientific requirements that can be used in resource mobilization towards current and future GCOS support and enhancements. A copy of *The Second Report on the Adequacy of GCOS* can be found on the GCOS home page at <http://www.wmo.ch/web/gcos/gcoshome.html>. As a follow-up to this report, the GCOS Secretariat in Geneva published an Implementation Plan for in October 2004 addressing the gaps identified and that plan is at the same address as the one noted for *The Second Report on the Adequacy of GCOS*. That plan can be found on the same web site.

As part of this global aspect of U.S. support for GCOS, and in response to a U.S. Presidential Climate Change Research Initiative (CCRI), the U.S. has formulated a Framework for International GCOS Support plan. This plan focuses on the status of GCOS, what is needed to bring GCOS to its operational-design level, and the support needed from the scientific, donor, and host communities to implement selected improvements to it.

Under the CCRI budget line for the support of atmospheric GCOS networks, NOAA has committed to selected improvements in the management and operation of GCOS and GCOS-related atmospheric networks beginning in 2003, and has taken leadership, working with the GCOS Secretariat at the WMO, in funding GCOS improvements. In line with that, the NOAA CCRI for the Global Climate Atmospheric Observing System budget for FY 2003 allocated a total of \$3.773M that begins to address the most critical needs and deficiencies of GCOS upper air observing sites in Chile, Congo, Cook Islands, Ecuador, Kenya, the Maldives, and Tanzania, as well as the establishment of new aerosol climate observing sites in the Maldives. In addition, this funding is used to: (1) Support the operations of the GCOS Secretariat; (2) stage GCOS regional workshops in developing countries; and (3) support critical GCOS data management activities at the GCOS Lead Data Center at NCDC in Asheville, North Carolina. The FY 2004 budget of \$3.787M continued the work begun in 2003 and expanded support to observing sites in Argentina, Armenia, Congo, Cook Islands, Costa Rica, Ecuador, Ivory Coast, Kenya, the Maldives, Namibia, the Philippines, and Zimbabwe. Plans for FY 2006 are dependent on the enactment of an FY 2006 federal budget, but planning continues on working with our partners in the GCOS community to identify more sites that can be aided.

One issue that the U.S. GCOS program is addressing is the continued operation of the Global Observing System Information Center (GOSIC) located at <http://gosis.org>. The GOSIC has recently completed a second-phase 3-year development effort at the University of Delaware. The U.S. GCOS Office is one of the sponsors of GOSIC along with the NOAA Office of Global Programs. In 2004, a final 2-year transition grant to the GOSIC was awarded, and the intent at this point is for the GOSIC to transition its operation to a permanent operational status at NCDC beginning in October 2006. During the transition, NCDC will work with international organizations, particularly the IOC's Global Ocean Observing System and the Food and Agriculture Organization's Global Terrestrial Observing System in order to ensure that the data requirements for all three GCOS domains (atmospheric, oceanic, and terrestrial) are fully met during this transition and into the new operations in Asheville at the beginning of FY07.

5.2 Regional Support

While the funding levels are not at the same levels as that of the U.S. global support for GCOS, it is far more focused on efforts dealing with regional workshops for developing nations, with a special emphasis on the South Pacific Island States' region.

The Regional Implementation Workshop, initiated by the GCOS in response to Decision 6/CP.5 of the UNFCCC and held in Apia, Samoa, in August 2000 with support and active participation by both Australian and U.S. experts, built on the South Pacific Regional Environment Program's (SPREP) needs analysis and has provided the basis for development of a Pacific Island-GCOS (PI-GCOS). The PI-GCOS Action Plan has identified the high priority actions, many of which can be implemented as stand alone modules that will assist in restoring and improving observing systems in the region to a level necessary to effectively monitor the climate of the region and systematically detect trends and changes in climate.

The U.S. GCOS Program Office in NOAA has been a supporter of the PI-GCOS effort since the Apia workshop and has contributed resources towards that effort. In FY 2000, the contribution to PI-GCOS was \$25K (U.S.) in support of the workshop; in FY 2001 and FY 2002 the combined contribution to PI-GCOS was an additional \$65K (U.S.) in support of the PI-GCOS Action Plan and Implementation Team meetings, and associated logistics. In FY 2003, support to SPREP amounted to \$105K; the additional funding included support for a data management workshop; as well as some support for related ocean observation work at the South Pacific Applied Geoscience Commission (SOPAC). Like support was provided for both the PI-GCOS and PI-Global Ocean Observing System (PI-GOOS) programs from FY 2004.

In FY 2005 the U.S. GCOS Program Office continued its support of the regional effort, and plans for

FY 2006 are to continue this support at levels consistent with previous years. These funds continue to address the actions and proposals from the PI-GCOS Action and Implementation Plans developed over the past couple of years. The U.S. GCOS Program Office also plans to continue contributing in-kind support and facilitation of furthering the goals of PI-GCOS as it has undertaken the role as the Secretariat of the region's PI-GCOS Science and Technology (S&T) Panel. The S&T Panel is a subsidiary body established to provide advice and guidance to the PI-GCOS Steering Committee. In addition to supporting GCOS regional efforts in the Pacific, the U.S. GCOS Program Office has also provided resources to help stage other workshops, as well as in providing presenters on various topics.

In support of the PI-GCOS effort, the GOSIC has developed, in concert with the regional PI-GCOS Program Officer, a new Pacific Islands GCOS portal in order to facilitate the access to Pacific Islands GCOS datasets that may be held in a diverse group of data centers. This portal, located at <http://pi-gcos.org>, has become a key tool to aid in the management of the Pacific Islands Regional GCOS Program, as well as providing an administrative tool for use by the regional program officer. That position is funded by the U.S. GCOS Program Office as part of the integrated Pacific Islands team effort of which the U.S. is an active participant along with Australia, New Zealand, and the member nations of SPREP. The regional portal has now also begun hosting web sites for various Pacific Island Meteorological Services which has been a great capacity building support activity for the region.

5.3 Bi-lateral Support

In the past year the U.S. (via the State Department) has entered into a number of important bi-lateral climate agreements. Specifically, the U.S. GCOS Program Office is involved in funding projects with Australia, China, New Zealand, and South Africa. These bi-laterals cover a wide range of projects dealing with climate prediction, ocean observing, stratospheric detection, water vapor measurements, capacity building and training, and communication of information, and will focus the attention and resources of all these countries towards developing a more sustainable and robust GCOS program.

In conjunction with the National Institutes of Water and Atmosphere (NIWA) in New Zealand, there are now two new projects which have been implemented on a long-term basis. The first one involves the implementation of a global stratospheric water vapor measurement station in Lauder, New Zealand. Water vapor is a key climate forcing agent, and this new monitoring site will complement an existing site in Boulder, Colorado, which has been taking similar high-quality upper air water vapor measurements since 1980. A second significant project involves the implementation of a new ship track for trace gas measurements that has been implemented on a car carrier ship on a route

between Nelson, New Zealand, and Nagoya, Japan. This is a brand new route and is unique in that it crosses both the Intertropical and South Pacific convergence zones; as such the principal investigators from NOAA and NIWA believe the sampling of trace gases on this route will hold great promise for new and useful data. To date three voyages have been successfully undertaken in May 2004, November 2004, and May 2005; in particular some interesting results involving the transport of methane from the Northern to Southern Hemisphere were observed during the May 2005 when the convergence Intertropical Convergence Zone was not in place. A paper on this will be forthcoming from the two Principle Investigators at NOAA and NIWA.

In conjunction with the Botswana Meteorological Service, the U.S. GCOS Program Office is also working to improve upper air observations in eastern and southern Africa via the establishment of an upper air maintenance and training facility. Joint work also continues on resurrecting the upper air station in Windhoek, Namibia, as well as in upgrading ozone measurements at the Cape Lookout Global Atmosphere Watch (GAW) station in South Africa. A similar ozone measurement enhancement project at the GAW site at Mt. Waliguan in China is also underway via the U.S./China climate bi-lateral agreement. In 2006, it is possible that a fourth GCOS Technical Support Project (TSP) for GCOS Maintenance will be established for South America. This would put TSPs in place for the Pacific Islands, Caribbean and Central America, South and East Africa, in addition to South America.

6. ENHANCED CLIMATE DATA MANAGEMENT IN THE PACIFIC

NOAA has recently taken a closer look at its data management activities in the Pacific Region. The International Pacific Research Center (IPRC) located at the University of Hawaii is a bi-lateral U.S./Japan activity that is funded by Japan, NOAA, and NASA. Specifically, NOAA funding is directed towards the operation of the IPRC's Asia Pacific Data Research Center (APDRC), and the U.S. GCOS Program Office also serves as the NOAA IPRC Program Manager. Links to the IPRC and APDRC can be found at <http://iprc.soest.hawaii.edu> and <http://apdrc.soest.hawaii.edu>.

The vision of the APDRC is to link data management and preparation activities to research activities within a single center, and to provide one-stop shopping of climate data and products to local researchers and collaborators, the national climate research community, and the general public. The mission of the APDRC is to increase understanding of climate variability in the Asia-Pacific region: by developing the computational, data management, and networking infrastructure necessary to make data resources readily accessible and usable by researchers; and by undertaking data-intensive research activities that will both advance knowledge and lead to improvements in data preparation and data products.

During the coming year in 2006, the APDRC will address the following activities: (1) Operate and continue the development of their Data Server System for serving data; (2) provide a global data archive and necessary data management for climate data and products; (3) conduct value-added activities that produce needed data products; (4) serve as a Global Ocean Data Assimilation Experiment (GODAE) Product Server for a broad range of research and application users with focus on satellite and model-derived products; (5) implement a high-resolution model for downscaling operational models in the Pacific Islands regions; and (6) assess and develop plans, in concert with the program manager at the Scripps Institution of Oceanography, for the data management needs of the Atmospheric Brown Cloud project (see <http://www-abc-asia.ucsd.edu>)

In September 2004 the U.S. GCOS Program Office staged a workshop in Honolulu to begin some planning for enhancing NOAA's data management efforts in the Pacific. Attendees included all NOAA line offices in the Pacific involved in environmental data management activities, the IPRC and APDRC, the East-West Center, and the U.S. Geological Survey. This was followed up by a second workshop in August 2005 where a number of funded data integration projects discussed in 2004 were reviewed and discussed.

The intent of these workshops was to look at how NOAA could begin to enhance its mission objectives to help meet critical regional needs for ocean, climate, and ecosystem information to protect lives and property, support economic development and enhance the resilience of Pacific Island communities in the face of changing environmental conditions by better integrating regional observations, research, assessment and services; strengthening the delivery of ocean, ocean-related, climate, ecosystem products and services to the diverse Pacific Island user community; and better supporting research and service programs in the Pacific.

In September 2005, a pilot data integration activity, initially entitled the NOAA Integrated Data and Environmental Applications (IDEA) Center, was begun under the auspices of NOAA's National Climatic Data Center. The genesis of the NOAA IDEA Center concept was included in NOAA's FY05 budget for better supporting Pacific environmental information activities. A significant part of the NOAA IDEA Center's work in FY05 was centered on the Pacific Region Integrated Data Enterprise (PRIDE) proposal process, in which 14 PRIDE proposals were funded in FY05 across four NOAA line offices using partnered joint resources with the International Pacific Research Center in the following three thematic areas: (1) Coastal and Climate Communities; (2) Marine and Coastal Ecosystems; and (3) Risk Management. More information about PRIDE can be found at <http://apdrp.soest.hawaii.edu/PRIDE/>.

NCDC is utilizing the East-West Center (EWC) in Honolulu, Hawaii, as the incubation facility for the NOAA

IDEA Center, and the new Center is participating in the planning process for occupying space in the new consolidated NOAA Pacific Regional Center planned to open in Honolulu in 2010. The initial core contract staff for the NOAA IDEA Center will consist of the following positions: (1) Director; (2) Data Integration Specialist; (3) Project Specialist for outreach and education; (4) IT Specialist; and (5) Administrative assistant.

Planned activities for the NOAA IDEA Center in FY 2006 include the following:

- Administration of the NOAA PRIDE proposal process for thematic data projects
- The performance of an inventory of Pacific Islands region ocean observing capabilities
- Begin planning for the interoperability aspects of data and observing systems related to supporting NOAA's climate and ocean observing programs
- Supporting the national Coastal Climatology program with emphasis in Hawaii & Alaska with associated user workshops
- Development of a first-order wave and water level product suite for the Pacific.

This activity also fits in quite well with a regional Task Team which has been established by the WMO in order to provide guidance and assistance in the designation and implementation process for establishing a Regional Climate Center (RCC) within the region. Such an RCC would aid in supporting climate prediction in the region via a virtual connection of various centers across the region in order to deliver more integrated climate data products and services to users, and it is expected that the NOAA IDEA Center would constitute a node in that structure to aid in both PI-GCOS and PI-GOOS regional data and information activities.

7. CONCLUSION

The U.S. has been very supportive of the overall international GCOS program effort and has provided considerable support on both a global, regional, as well as bi-lateral basis. It is believed that support for GCOS should be global in nature and the U.S. is working to be a leader in helping to make GCOS a sustainable and robust system both regionally and globally, and that can serve the needs of an improved global climate monitoring system that will be part of the Global Earth Observing System of Systems (GOSS) being planned internationally by more than 60 nations and 40 international organizations; see the following URL for more details: <http://earthobservations.org>.

In summary, the inception of the U.S. GCOS Program Office in 1999, coupled with the resources provided via the CCRI program has led to a robust and active U.S. GCOS program which has been working with a number of partners in order to provide support across a broad range of international, regional, and bi-lateral climate activities that are leading to progress for GCOS.

The U.S. in partnership with Australia, New Zealand, and the nations of the South Pacific Regional Environment Program have taken the lead in working towards establishing a robust and sustainable Pacific Islands Global Climate Observing System (PI-GCOS) that meets the climate change and variability observations, and application needs of the PI nations and meets the associated regional and international requirements for climate observing in this data sparse area. The PI-GCOS Action Plan developed in 2002 has identified the high priority actions, many of which can be implemented as stand alone modules that will assist in restoring and improving observing systems in the region to a level necessary to effectively monitor the climate of the region and systematically detect trends and changes in climate primarily via support for GCOS Surface Network and GCOS Upper Air Network sites across the region.

The U.S. GCOS Program Office, based at NOAA's National Climatic Data Center (NCDC), has been a primary supporter of the PI-GCOS effort since the first regional GCOS workshop in Apia, Samoa, in August 2000, and has contributed resources towards that effort. Since 2000, support for PI-GCOS from the U.S. has amounted to \$350K (US). These funds continue to address the actions and proposals from the PI-GCOS Action and Implementation Plans developed over the past couple of years. The U.S. GCOS Program Office also plans to continue contributing in-kind support and facilitation of furthering the goals of PI-GCOS as it has undertaken the role as the Secretariat of the region's PI-GCOS Science and Technology (S&T) Panel. The S&T Panel is a subsidiary body established to provide advice and guidance to the PI-GCOS Steering Committee. In addition to supporting GCOS regional efforts in the Pacific, the U.S. GCOS Program Office has also provided resources to help stage other workshops, as well as in providing presenters on various topics.

In support of the PI-GCOS effort, the Global Observing System Information Center (GOSIC), a data management facility supported by NOAA/NCDC has developed, in concert with the regional PI-GCOS Program Officer, a new Pacific Islands GCOS portal in order to facilitate the access to Pacific Islands GCOS datasets that may be held in a diverse group of data centers. This portal, located at <http://pi-gcos.org>, has become a key tool to aid in the management of the Pacific Islands Regional GCOS Program, as well as providing an administrative tool for use by the regional PI-GCOS program officer based at the Secretariat of the Pacific Regional Environment Program (SPREP) in Apia. That position is funded by the U.S. GCOS Program Office as part of the integrated Pacific Islands team effort of which the U.S. is an active participant along with Australia, New Zealand, and the member nations of SPREP.

The Pacific Islands are part of WMO's Regional Association V. Since 2002, the level of reporting of monthly CLIMAT messages from the

152 GSN stations in Region V which has risen steadily and has reached the 80 percent level over the past two years. It is our hope to continue to improve that via the regional PI-GCOS program.

The GCOS Lead Data Center for GSN data at the NOAA's National Climatic Data Center (NCDC) has been designated as the repository for historical GSN data. Through the work of NCDC as well as through the regional PI-GCOS program, the accomplishment of achieving partial or complete historical daily data holdings to GSN Archive at NCDC from all 152 stations in the region has been achieved. The region is to be commended for the enormous improvement made over the past 4 years in providing such critical data to the GSN Archive. GUAN performance is also generally good, and has been improving and this is primarily attributed to the work of the regional PI-GCOS Program in retrofitting GUAN systems and in providing expendables such as radiosondes and balloons.