CGMS-39, NOAA-WP-12
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NOAA Report on the Global Cryosphere Watch

In response to CGMS Action 38.10

This paper provides information to CGMS-39 on activities at NOAA/NESDIS/STAR with respect to the new WMO Global Cryosphere Watch (GCW). The paper presents a brief background of GCW and a description of potential contributions from CGMS members.

Report on the WMO Global Cryosphere Watch

1. Introduction

This paper provides information to CGMS-39 on activities at the NOAA National Environmental Satellite, Data, and Information Service (NESDIS) which may contribute to the World Meteorological Organization's Global Cryosphere Watch (GCW) program. The paper provides a description of GCW and suggests ways that NESDIS and other CGMS members can contribute. The paper is in response to Action 38.10:

CGMS Members are invited to support the Global Cryosphere Watch (GCW) by identifying relevant operational satellite products, and developing new satellite derived climate products, which would contribute to GCW and to comment on the benefit of cryosphere reference sites that meet long-term in-situ needs as well as satellite cal/val needs.

2. Background

The cryosphere collectively describes elements of the Earth System containing water in its frozen state. It includes solid precipitation, snow cover, sea ice, lake and river ice, glaciers, ice caps, ice sheets, permafrost, and seasonally frozen ground. The cryosphere is global, existing not just in the Arctic, Antarctic and mountain regions, but at all latitudes and in approximately 100 countries. Frozen water and its variability and change in the atmosphere, on land, and on the ocean surface has direct feedbacks within the climate system, affecting energy, moisture, gas and particle fluxes, clouds, precipitation, hydrological conditions, and atmospheric and oceanic circulation. The cryosphere provides some of the most useful indicators of climate change, yet is one the most under-sampled domains of the Earth System. Improved cryospheric monitoring is essential to fully assess, predict, and adapt to climate variability and change.

All of these issues require a coordinated international and cross-disciplinary mechanism, thus a proposal by Canada was presented to the WMO Congress in 2007 for the establishment of an operational Global Cryosphere Watch (GCW). In 2009, WMO created an Executive Council expert panel on Polar Observations, Research, and Services (EC-PORS), and encouraged the panel to lead the development of the GCW concept. An EC-PORS GCW task team was created, with NOAA playing a leading role. A GCW implementation strategy was developed and presented to the 16th WMO Congress in May 2011. Congress approved GCW as an official WMO program.

3. Mission and Objectives

GCW will be an international mechanism for supporting all key cryospheric in-situ and remote sensing observations, from research and operations, and for implementing the recommendations of the Integrated Global Observing Strategy Partnership (IGOS-P) - Cryosphere Theme (hereinafter "CryOS", the cryosphere observing system).

To meet the needs of WMO Members and partners in delivering services to users, the media, public, decision and policy makers, GCW will provide authoritative, clear, and useable data, information, and analyses on the past, current and future state of the cryosphere. In its fully developed form, GCW will include observation, monitoring, assessment, product development, prediction, and research. It will provide the framework for reliable, comprehensive, sustained observing of the cryosphere through a coordinated and integrated approach on national to global scales and deliver quality-assured global and regional products and services. GCW will organize analyses and assessments of the cryosphere to support science, decision-making and environmental policy. To meet these objectives, GCW will encompass:

Requirements: Meet evolving cryospheric observing requirements of WMO Members, partners, and the scientific community, by making CryOS a living document and contributing to the WMO Rolling Review of Requirements (RRR) process;

Integration: Provide a framework to assess the state of the cryosphere and its interactions within the Earth System, emphasizing integrated products using surface- and space-based observations, while including a mechanism for early detection of, and support for, endangered long-term monitoring series, aimed at optimizing knowledge of environmental conditions and exploiting this information for predictive weather, climate and water products and services;

Standardization: Enhance the quality of observational data by improving observing standards and practices for the measurement of cryospheric variables, by addressing differences and inconsistencies in current practices used by Members, partner organizations and the scientific community;

Access: Improve exchange of, access to, and utilization of observations and products from WMO observing systems and those of its partners;

Coordination: Foster research and development activities and coherent planning for future observing systems and global observing network optimization, especially within the WMO Integrated Global Observing System (WIGOS), by working with all WMO Programmes, technical commissions (TCs), regional associations (RAs), partner organizations and the scientific community.

GCW will be an essential component of WIGOS and will coordinate cryospheric activities with the Global Climate Observing System (GCOS), which includes the climate-related components of the Global Ocean Observing System (GOOS) and the Global Terrestrial Observing System (GTOS), enhancing GCOS support to the UNFCCC. GCW will strengthen the WMO contribution to the Global Framework for Climate Services (GFCS). Through WIGOS and the WMO Information System (WIS), GCW will also provide a fundamental contribution to the Global Earth Observation System of Systems (GEOSS).

4. Observing the Cryosphere

A comprehensive cryosphere observing system must be a combination of ground-based instrumentation, satellite remote sensing, aircraft measurements, modeling, and data management. Conditions in areas where the cryosphere exists are harsh, and in situ observations there are difficult and expensive. The complex system of satellites is essential for delivering sustained, consistent observations of the global cryosphere and are a key to extending local in situ measurements. No one all-encompassing sensor exists; rather, the combination and synthesis of data from different yet complementary sensors is essential, and underlines the critical importance of maintaining key synergetic elements of the system. Surface and airborne observations provide data that cannot be measured from space, more detailed information in critical areas, and observations with which to validate satellite retrievals.

Together, in situ, satellite, and aircraft measurements cover all scales of observation, providing the data needed for small-scale process studies and global climate prediction. As robust as the cryosphere observing system is, many surface-based observation networks have been reduced and some, decommissioned. Monitoring efforts are in need of sustained funding. Space-based capabilities for some snow/ice properties are extremely limited. There needs to be a concerted effort to improve and expand systematic, comprehensive, ground-based monitoring, and to support development of remote sensing methods and products.

Figure 1: The cryosphere observing system is comprised of surface, aircraft, and satellite measurements. (Credits SHEBA; Chinese Meteorological Administration; John Cassano (U Colorado); NOAA/NOHRSC; NASA)

5. Near-Term Tasks and Relevance to CGMS

The following GCW tasks have been identified for the next 1-2 years:

1. Implement recommendations of the IGOS Cryosphere Theme;
2. Initiate pilot and demonstration projects;
3. Establish cryosphere reference sites;
4. Develop an inventory of satellite products for GCW;
5. Develop a web portal and interoperability for cryosphere users and providers;
6. Capacity building;
7. Communication and outreach.

Of particular relevance to CGMS is the task to develop an inventory of satellite products for GCW. This involves creating an inventory of candidate satellite products that are mature and generally accepted by the scientific community. It includes an intercomparison of products to assess quality and to ensure an authoritative basis. The assessment is more important than the inventory itself, as it provides the information necessary to produce a recommendation on the relevance of each satellite product to GCW.

Two recent workshops are important here. The World Climate Research Programme (WCRP) Climate and Cryosphere Project (CliC) sponsored a workshop in early 2011 on the evaluation of satellite-derived sea ice extent and concentration products. This task was identified as a pilot project in the GCW feasibility study. The results of the intercomparison provided valuable information to GCW on the many available products and on the process for determining "authoritative" information. The WCRP Observation and Assimilation Panel (WOAP) also held a workshop in 2011 on essential climate variables (ECVs). It was decided that an inventory of satellite and in situ ECV products will be compiled with information on product maturity, accuracy, users, applications, and adherence to the GCOS guidelines for ECV datasets. Some programs that can contribute to this are already underway. For example, the United States National Oceanic and Atmospheric Administration (NOAA) is supporting work on satellite-derived climate data records (CDRs) for snow and ice, and the European Space Agency (ESA) Climate Change initiative will provide ECVs that meet GCOS requirements, and will support efforts to validate and improve current methods for extracting cryospheric geophysical parameters from satellite data. It is likely

that the inventory will be established at the NOAA Global Observing Systems Information Center (GOSIC), and the admission of new datasets into the inventory will be managed by the GCOS Panels.

These activities, and others, should continue. The Polar Space Task Group (PSTG) of EC-PORS, formerly the WMO Space Task Group for the International Polar Year, with its direct connection to space agencies, will work with GCW to identify new satellite products to support GCW pilot projects and services. **CGMS is also well positioned to contribute to this task. CGMS Members are encouraged to assess their operational and research products for applicability to GCW objectives.**

Another task that is relevant to CGMS is the identification of ground stations, or "reference sites". GCW will initiate a comprehensive cryosphere observing network called "CryoNet", a network of reference sites or "supersites" in cold climate regions, on land or sea, operating a sustained, standardized programme for observing and monitoring as many cryospheric variables as possible. CryoNet will provide reference sites for validation of satellite and model outputs. As encouraged by GCOS, GCW will facilitate the establishment of high-latitude supersites with co-located measurements of key variables. GAW stations and WCRP/Coordinated Energy and Water Cycle Observations Project (CEOP) reference sites in cold climates are potential candidates.

WMO Members, through their cryosphere focal points, are being asked to recommend suitable sites. China has established supersites in the "Third Pole" region where the High Asian cryosphere (HAC) serves as the Asian "water tower" for over a billion people. They would like to merge into the proposed GCW network and help lead the development of standardized cryosphere observing programmes. Another proposed contribution is the Sodankylä-Pallas supersite in the boreal forest of northern Finland. Its infrastructure is designed for integrated monitoring of soil-snow-vegetation-atmosphere interaction and provides reference measurements for satellite sensors on a continuous basis.

As the reference sites will provide data that is useful for the validation of satellite products, **CGMS is encouraged to comment on the types of measurements and locations that best satisfy the needs of its member**. Furthermore, **CGMS should consider having a representative within the GCW organizational structure**, either on the GCW advisory group or one of its expert teams.

6. NOAA Contributions

NOAA has been contributing to the development of the GCW concept and implementation strategy through EC-PORS. This involvement is expected to continue. NOAA is also involved in the development of satellite products that could be useful to GCW, both climate data records and real-time products. In particular, a 28-year times series of sea ice cover and thickness from Advanced Very High Resolution Radiometer (AVHRR) data has recently been produced. An example of ice thickness from AVHRR is shown in Figure 2. The ice cover, concentration, thickness, motion, and surface temperature algorithms developed for GOES-R and NPP/JPSS can be applied to current AVHRR and Moderate Resolution Imaging Spectroradiometer (MODIS) data for real-time processing, providing information on the state of the cryosphere.

Through its Climate Data Records Program, NOAA is supporting the transition of a variety of snow and ice products to "operational" environments, either the National Climatic Data Center (NCDC) or collaborating data centers such as the National Snow and Ice Data Center (NSIDC). The Cryosphere Product Development Team created under this program is providing coordination for the generation, validation, and archival of fundamental and thematic snow and ice climate data records (CDR) that the scientific community can use to help answer questions about a changing climate. These are ideal products for GCW.

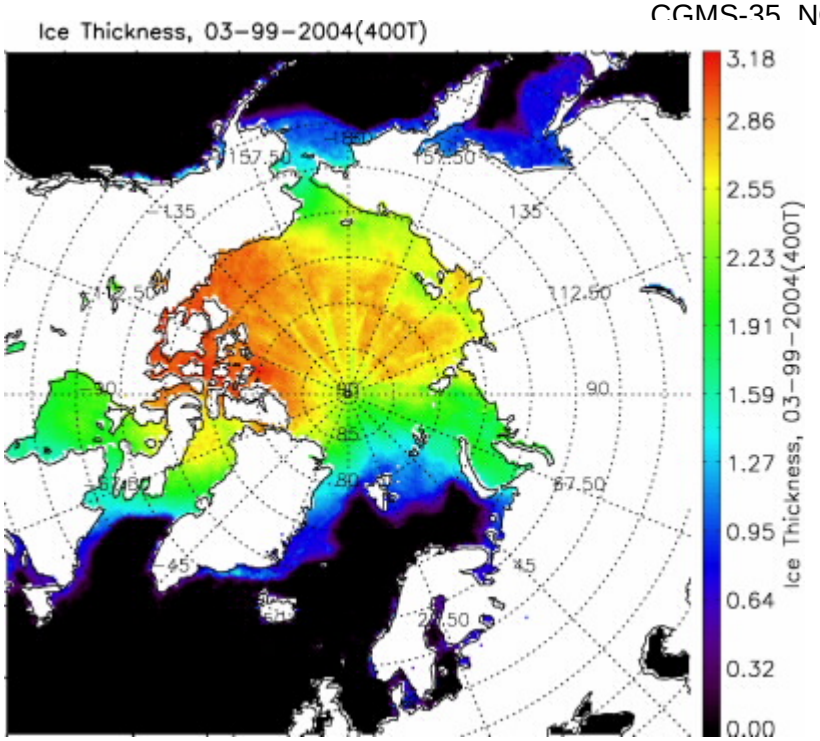

Figure 2: Arctic Ocean sea ice thickness estimated with AVHRR data, composited over March 2004.

With regard to reference sites, NOAA operates surface meteorological stations at Barrow, Alaska and South Pole that may be of interest to GCW. Discussions on potential contributions will be initiated in the near future.