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NOAA'S APPROACH TO PROVIDING CLIMATE DATA RECORDS (CDRs)

As part of its climate mandate, NOAA has a responsibility to provide the United States with objective data and tools to help it characterize, understand, predict, mitigate and adapt to climate change and variability. To help fulfill that responsibility, NOAA has begun working with other federal agencies to coordinate the respective Climate Data Record (CDR) activities.

National Climatic Data Center (NCDC) initiated the Climate Data Record (CDR) Project to lead the Agency's CDR activities and to coordinate with the partner agencies. Given that early algorithm development is supported elsewhere, the CDR Project is focused on the generalization and application of mature algorithms to multiple satellites and sensors which together span climate-relevant time periods. It will also emphasize development and generation of Climate Information Records (CIRs), defined as time series of CDR-derived metrics tailored for specific users communities (e.g., hurricane trends, arctic sea ice coverage, coastal inundation). The CDR Project expects to execute its responsibilities in partnership with the larger scientific community through annual NOAA Announcements of Opportunity -- open to academic, commercial, non-profit and government proposers -- as well as through community reviews and working groups.

Collaboration with the international community on developing intercalibrated satellite observation datasets and downstream climate data and information records are being done through the WMO Space Programme **G**lobal **S**pace-based **I**nter**C**alibration **S**ystem (GSICS) and **S**ustained, **C**o-**O**rdinated **P**rocessing of **E**nvironmental Satellite Data for **C**limate **M**onitoring (SCOPE-CM) projects, with further collaboration with the World Climate Research Programme (WCRP).

We invite CGMS members to provide ideas for additional SCOPE-CM pilot CDR projects as well as identifying their needs for Climate Information Records to CGMS and the SCOPE-CM Executive Panel.

NOAA'S APPROACH TO PROVIDING CLIMATE DATA RECORDS (CDRs)

1. INTRODUCTION

The challenges of detecting, understanding and projecting the impacts of climate change require high quality global data collected consistently over decades. In the nearly 50 years of meteorological satellite observations, NOAA's satellite data have increasingly been used to complement research satellite data for purposes of observing climate processes and monitoring change. However, absent today's heightened concerns about climate change, many of the early research and meteorological satellites were either not designed for climate-quality measurements or were not succeeded at the end of their lifetimes. The resulting patchwork of satellite measurements has required extraordinary scientific effort to yield credible climate information. The challenge has been compounded by the absence of comprehensive and sustained funding programs for satellite climate records. In recent years, key scientific and policy organizations (e.g., Global Climate Observing System [GCOS], U.S. Climate Change Science Program [CCSP]) have independently articulated a pressing need for multiple climate observing systems with dedicated analysis programs to obtain authoritative climate change records (WMO, 2003; CCSP, 2006; IPCC, 2007; NRC, 2007).

As part of its climate mandate, the National Oceanic and Atmospheric Administration (NOAA) has a responsibility to provide the United States with objective data and tools to help characterize, understand, predict, mitigate and adapt to climate change and variability. To help fulfill that responsibility, NOAA has begun coordinating its Climate Data Record (CDR) activities with other agencies through the CCSP. The National Research Council defines a CDR as "a time series of measurements of sufficient length, consistency, and continuity to determine climate variability and change" (NRC, 2004).

NOAA's National Climatic Data Center (NCDC) initiated the Climate data record (CDR) Project (hereafter referred to as the Project) to lead the Agency's CDR activities (Bates, 2004; Privette, 2008). The Project will largely execute its activities through competitive grants and contracts, and will emphasize interagency coordination in moving technologies from research programs to operations at NCDC and in other parts of NOAA. It is designed for sustained implementation, such that mature CDRs can be subjected to further improvements crafted through parallel research programs as new measurements and observing systems become available.

Given that early algorithm development is supported elsewhere, the Project is focused on the generalization and application of mature algorithms to multiple satellites and sensors which together span climate-relevant time periods. It also supports development of Climate Information Records (CIRs), defined as time series derived from CDRs and related long-term measurements that provide specific information (e.g., drought area, hurricane trends) about complex environmental phenomena in a manner useful to a variety of applications and user communities (Privette, 2008). Together, the various CDR products serve a wide range of scientific, commercial, decision support and policy-making needs.

Various CDRs have been developed in the past, most notably through the NOAA-NASA Pathfinder Program in the 1990s (Ohring and Dodge, 1992). NOAA intends to leverage lessons from such efforts into a more systematic, comprehensive and sustained program. To help achieve this, the Project plans to execute its responsibilities in partnership with the larger scientific community through regular NOAA Announcements of Opportunity as well as

through community reviews and working groups. The Project represents one of NOAA's primary contributions to the CCSP's climate data goals.

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2. PROGRAM PRIORITIES

The CDR Project provides fundamental and geophysical CDRs per the recommendations of the CCSP, the GCOS, and the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (WMO, 2003; CCSP, 2006; IPCC, 2007). The Project organizes CDRs according to the parameter contributions to major environmental phenomena (e.g., water cycle, carbon cycle, energy budget). The Project systematically addresses different phenomena over time, such that a contemporaneously developed CDR suite is coherent and complementary. The Project expects that this approach will facilitate timely integrated analyses of key climatic systems.

To date, many robust and validated satellite algorithms have been developed through NASA’s Earth Observing System (EOS) science teams, NOAA’s Center for Satellite Applications and Research (STAR), and other organizations (e.g., King et al., 2004). The algorithms quantitatively retrieve key earth system parameters, but often were developed to work with a single satellite instrument. In many cases, these algorithms are now appropriate for generalization and application to a longer time series of observations and execution in a sustained production environment.

The Project will provide both support and a formalized framework within which to achieve algorithm maintenance, validation and product analysis. The Project intends to develop CDRs using applicable data from current and heritage satellites (research and operational), including some of the earliest space platforms. Further, the Project seeks to ensure that its algorithms and tools are extendable to future satellite observations, especially those from the Nation's forthcoming NPP, NPOESS and Jason missions. In many cases, mature satellite CDR algorithms are augmented by non-satellite data. The Project's goal is to extend proven algorithms to a sufficiently large set of observations that near-seamless long-term aggregate records are obtained. Application of same or similar algorithms across different satellites, when practical, allows development of homogeneous error structures - a key Project goal. The Project expects rigorous error analysis for all CDRs.

To meet the Nation's diverse climate product needs, two unique production contexts are typically required. Many algorithms must be executed within weeks of the observations to provide ongoing inputs to intra-seasonal applications and research. However, these "initial production" climate products typically do not meet the more rigorous uncertainty specifications of retrospective climate data analysis. Therefore, more accurate and precise climate products are generated through data reprocessing following significant time lapses (typically years). The longer latency allows for incorporation of improved spacecraft, instrument, and algorithm knowledge, as well as for improved ancillary and auxiliary data. The Project supports both production contexts.

The Project will conduct most initial CDR algorithm activities through competed Product Development Teams (NRC, 2005). The Teams will be responsible for developing an algorithm and production framework that achieves Project goals. In the near term, the Project expects many or most Development Teams to generate and validate their products at their home institutions or in partnership with federal laboratories. Over the longer term, NOAA may seek to consolidate some or all routine production activities around its operational Centers and/or NOAA Cooperative Institutes.

After an initial grants period to adapt proven algorithms to a succession of satellites or sensors, the Project anticipates competing algorithm maintenance contracts to ensure continuing algorithm reliability with current and future satellite data. It also anticipates routinely competing product validation and analysis grants to maintain high quality results. Product approach and maturity will be regularly reviewed by an independent community-based Climate Record Working Group composed of outstanding climate science leaders and other stakeholders (e.g., NRC, 2005).

NOAA's CDR Project is strongly focused on building a well-conceived and durable approach to the CDR information preservation. To ensure maximum societal benefit, the Project puts significant emphasis on the quality and transparency of its processes and products. To meet these and others objectives associated with an operational agency, the Project's codes, products and tools adhere to and/or extend best practices as developed through heritage research and operational programs, including NASA's Earth Observing System (EOS; e.g., King et al., 2004). The disciplined use of such practices will help ensure maximum scientific value, information preservation and long-term societal benefit at reasonable lifecycle costs (NRC, 2005).

3. INITIAL PROJECT FOCUS AREAS

The President's Fiscal Year (FY) 2009-2014 budget identifies initial dedicated funding for NOAA's CDR efforts as addressed by the Project.

To provide building blocks for future CDR development, the Project is initially focused on Fundamental CDRs (FCDRs, i.e., calibrated and quality-controlled long term sensor data records that have been improved over time) (NRC, 2004).
In FY 2009, the Project will focus on:

- Multispectral Imager(s) Solar Reflective SDR
- Mutispectral Imager(s) Thermal Emissive SDR
- Total Ozone Sensor(s) (Nadir) SDR
- Ozone Profile Sensor(s) (Limb) SDR
- Microwave Sounder(s) SDR
- Thermal Infrared Sounder(s) SDR
- Radiation Budget Sensor(s) SDR

Note: SDR=Sensor Data Record, or climate-quality calibrated and geo-located 5 radiances, reflectances, temperatures and/or radar return, as appropriate for the sensing technology.

The Project is also addressing a small set of lower complexity Thematic CDRs (TCDRs, i.e., geophysical variables, such as sea surface temperature, that are derived from FCDRs) in its initial years. The Project's current phenomenological focus is on the Earth's energy and water

cycles. Therefore, the Project will pursue TCDRs whose parameters comprise or impact these cycles.

The Project anticipates challenges in generalizing and transitioning research developments into an operational framework. Therefore, it is initially focusing on a small group of pathfinding efforts that strongly leverage community CDR knowledge in routine processing. Throughout its initial years, the Project will seek to develop and provide CDRs which address outstanding challenges identified in the IPCC Fourth Assessment Report (IPCC, 2007) or other specific societal benefit areas (e.g., those identified in the Global Earth Observation System of Systems - GEOSS framework).

To ensure maximum return on the Nation's NPP and NPOESS satellites, the Project is also emphasizing CDRs whose source data will include those from these satellites as well as the Jason-series platforms.
The Project expects to rely on a wide variety of contributions to reach its goals, and will particularly require collaboration among experts in the climate, remote sensing and data management communities, who work closely with and are informed by feedback from various user and stakeholder communities. In addition to normal science community groups, the stakeholders will private industry, government and other resource managers and decision makers.
To help ensure stakeholder trust and support, the Project will conduct community workshops in which it will explain the theoretical basis of CDR algorithms and the proposed CDR development approaches. Community input and suggestions will be solicited and incorporated, as appropriate.

To ensure its CDRs are scientifically-defensible, traceable and transparent, Project developments will be open to public inspection and scrutiny, as well as independent generation of repeatable results (NRC, 2005). Products and supporting information (including source codes) will be available through NOAA Data Center(s) for public accessibility, preservation and stewardship.

2. CONCLUSIONS

The President's FY 2009 budget provided a 5-year start to NOAA's new Climate Data Record Project. The Project is designed to complement and systematically continue the developments yielded by CDR research activities at NOAA and in other federal agencies (e.g., NASA, USGS). NOAA's CDR Project has been rigorously reviewed by the NRC and will seek to build upon and leverage the lessons learned from the Pathfinder, EOS and other successful programs. The Project is currently funding an initial set of Fundamental Climate Data Records (FCDRs; similar to NASA Level 1b products) and lower complexity Thematic Data Records (TCDRs; similar to NASA Level 2+ products). In 2009, the Project is focused on CDRs which contribute to an understanding of Earth's water and energy cycles. In future years, other key Earth climate system cycles and components will be addressed. NOAA intends to continue this Project indefinitely such the Nation remains equipped with the data sets required to solve critical climate questions and issues that may impact the well-being, economic vitality, property and security of the population.

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