8.4 SUSTAINED COORDINATE PROCESSING OF ESSENTIAL CLIMATE VARIABLES AT THE NATIONAL AND INTERNATIONAL LEVELS

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ABSTRACT

NOAA has restored satellite climate sensors to provide continuity of observations of the Essential Climate Variables (ECVs) of solar irradiance, Earth radiation and clouds and sea level rise. This marks the transition of these observation and processing capabilities from research to operations to ensure their sustained production. Maintaining the high quality level required of ECVs entails the continuing involvement of the research community as they are moved into the operational environment at NOAA. We summarize the latest efforts in development at the National level for these ECVs. At the international level, the World Meteorological Organization Space Program has begun a project called Sustained, Coordinated Processing of Environmental Satellite Data for Climate Monitoring (SCOPE-CM). The goal of SCOPE-CM is to establish a network of facilities to ensure the continuous and sustained provision of high quality satellite products related to the ECVs. Progress in this effort will also be summarized.

1. Climate Sensor Status and Update

During the Nunn-McCurdy process, ground rules endorsed by the NPOESS Executive Committee (EXCOM) stipulated that a higher priority be placed on the continuity of legacy operational capabilities in support of weather measurements, which resulted in alower priority for climate-focused measurements. The Office of the Secretary of Defense (OSD) led a tri-agency process culminating in the certification of a restructured NPOESS Program on June 5, 2006. The certified program is described in the following language taken from the Acquisition Decision Memorandum:

• The NPOESS Certified Program now includes the following sensors:

Visible/Infrared Imager/Radiometer Suite (VIIRS); Microwave Imager/Sounder; Search and Rescue Satellite Aided Tracking (SARSAT); Cross-track Infrared Sounder (CrIS); Advanced Technology Microwave Sounder (ATMS); Advanced Data Collection System (ADCS); Cloud's and Earth's Radiant Energy System (CERES); Ozone Mapping and Profiling Suite (OMPS) Nadir; and the Space Environment Monitor (SEM);

• It does not include funding for the following sensors:

Aerosol Polarimetry Sensor (APS), Total Solar Irradiance Sensor (TSIS); OMPS-limb; Earth Radiant Budget Suite (ERBS); Altimeter (Alt); Survivability Sensor (SuS); and Full Space Environment Sensors (SESS); however, the program will plan and fund for the integration of these sensors onto the satellite buses, if the sensors are provided from outside the program (emphasis added by NASA and NOAA);

• It also terminates the Conical Scanning Microwave Imager/Sounder (CMIS), while developing a competition for a new, less expensive Microwave Imager/Sounder (MIS) starting with the second Engineering, Manufacturing, and Development (EMD) satellite; and

• It is now a two-orbit rather than three-orbit program that uses data from the European Meteorological Operational (MetOp) satellites provided by the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT) for the mid-morning orbit, while providing flexibility to deploy Defense Meteorological Satellite Program (DMSP) satellites depending on the health of the constellation in either early-morning or mid-morning orbits. Figure 1 shows the configuration of the Certified NPOESS program as of the summer of 2006.

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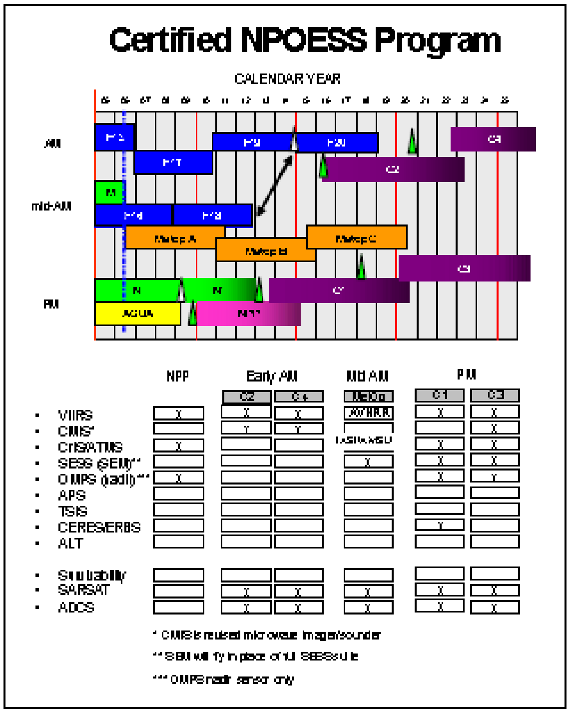

Figure 1. Status of the NPOESS Program following the down scoping following the Nunn-McCurdy process.

2. Recovery of Climate Sensors

The loss of the climate sensors (i.e., the OMPS-Limb, APS, TSIS, CERES/ERBS, and ALT) on NPOESS caused great concern in the climate community because records established over several decades would end. The White House Office of Science and Technology Policy (OSTP) requested that NASA and NOAA study the impacts of these losses. For that study, NASA and NOAA established measurement priorities based on the following criteria: 1) Continuation of NASA's Earth Observation System (EOS) capabilities and observations that allow for the monitoring, understanding, and prediction of climate variability and change, and 2) Extension of existing Climate Data Records (CDRs) – developed to address GCOS and CCSP measurement priorities--rather than the initiation of new CDRs. Study concluded that the loss of the sensors would have significant negative impact on the ability to observe essential climate variables. As a result OSTP asked NASA and NOAA to study alternatives to recover the capabilities of the lost sensors. This recovery effort currently is focusing on the following options to bring back sensors;

- The CERES will fly and instrument on the NPP, NPOESS C1 and future afternoon orbit. The NPP will use a FM-5 instrument (following instruments FM-1and 2 on the NASA TERRA satellite and FM-3 and 4 on the AQUA satellite) and FM-6 in NPOESS C-1. Future instruments will involve a new procurement.
- The TSIS will fly on NPOESS C1 and future instruments will fly at 5 year intervals on platforms to be decided
- The OMPS-Limb sounder will be added back to the NPP mission, will miss the NPOESS-C1 mission but will be added back to future OMPS sensors
- The altimeter mission will maintain continuity with the procurement of the Jason-3 mission in the exact repeat orbit of prior altimeter missions
- The APS will remain as a placeholder in NPOESS C3 pending flight on the NASA Glory mission

3. NOAA's Climate Data Record (CDR) Program

The CDR Program addresses NOAA's Strategic Goal to "Understand climate variability and change," and the NOAA Climate Goal's mandate to "provide comprehensive observations, data and analysis systems, climate data records …which can address the current state of the climate at the accuracies and resolution required by the users; [and] to provide capability to assimilate large and complex data sets into earth systems models..."

CDRs are distinct from operational weather/hazard satellite products since CDR production:

- Removes/minimizes time dependent biases in satellite data
- Delivers long term "seamless" homogeneous records characterizing climate change/variation (50+ years)
- Reprocesses the entire period of record as new climate algorithms or sensor knowledge are developed.

NOAA's CDR Program is initially focused on critical CDRs that address key societal issues including:

- Water, drought, floods
- Energy, renewable energy
- Hurricanes, coastal hazards.

Improved knowledge in these areas translates into lives and property protected or saved, as well as economic resiliency and national security
NOAA's Climate Data Record Program provides for ongoing production of Climate Data Records (CDRs) and Climate Information Records (CIRs). CDRs and CIRs provide authoritative climate reference sets. They are required by scientists to detect, assess, model and predict climate change, and by decision-makers to devise effective strategies to respond, adapt, and mitigate the impacts of climate change. The Program is primarily executed through

competitive grants and NOAA Cooperative Institutes) and contracts.

The Program leverages prior U.S. investments by transitioning research products from NASA and other agencies into sustained NOAA operations. Major CDR development and production actions include:

- Algorithm Development, Processing and Re-Processing of Long Term Data Series
- Calibration, Validation and Characterization of Data
- Science and Climate Information Records
- Long Term Stewardship (ensure CDRs are easily understood and accessible and of highest quality possible)
- Applications for Mitigation and Adaptation, and
- Project Management Support

This Program officially started in 2009 with activities in three major thrust areas: processing of historical operational environmental satellite data for long-term CDRs, development of software for NPP pre-processing to ensure NPP data are easily available for processing into CDRs (a format we are calling a raw CDR), and implementation planning for processing of the TSIS and CERES data for the C1 NPOESS.

4. International Coordination on Climate Data Records

The aim of the **S**ustained, **C**o-**O**rdinated **P**rocessing of **E**nvironmental Satellite Data for **C**limate **M**onitoring (SCOPE-CM) is to establish a network of facilities internationally ensuring continuous and sustained provision of high-quality satellite products for ECVs, on a global scale, responding to the requirements of the Global Climate Observing System (GCOS). This effort, organized through the WMO, focuses on the end-to-end international coordination to sustain the global satellite observing system, provide intercalibration of elements of that system, and ensure processing and stewardship of those data into trustworthy products. The suite of international activities involved in this system are illustrated in Figure 2.

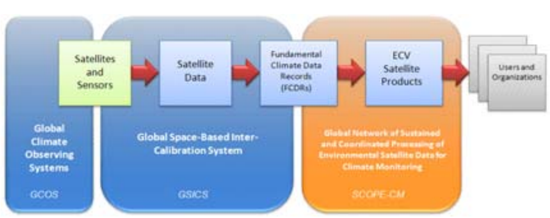

Figure 2. End-to-end international coordination in production of Essential Climate Variables.

At the first SCOPE-CM planning meeting held in Darmstadt in April 2008, five topics were identified for initial activities:

- AVHRR based data set of cloud and aerosol properties
- SSM/I: total column water vapour, precipitation, liquid water path
- Surface albedo, clouds and aerosols from geostationary satellites
- Atmospheric Motion Vectors (AMV) and clear sky radiance
- Upper tropospheric humidity

Work by the host countries participating in SCOPE-CM is currently under way on each project.

5. The Roles of the CDR Program and SCOPE-CM in National and International Climate Services

Climate services is a fairly new term that involves the routine production of climate information relevant to a wide range of time scales and across a set of disparate disciplines. The time scales and disciplines range from seasonal to interannual, for example the observation and prediction of climate extremes and related societal impacts, to long-term planning for resource management and infrastructure development over decades, for example forest resource management. Delivering services, which are intangibles that have value, is complex because you need to manage a range of disparate disciplines and, thus, the value proposition is in the way you manage and add value to information. The critical challenge for climate services is to make connections and transform ad hoc research use of observations and models into routine and sustained products accessible to the non-expert community. The non-expert community is most interested in the application of a time series of either observations or models at a location for a limited region. As a result, there is an increasing need for long-term, fine scale observations and for developing relationships between climate models run at course scales and finer resolution observations or models.

Downscaling is the term applied to the process of generating higher resolution observations were projections from course to resolution observations or models. There are three categories of downscaling techniques: 1) nesting a regional climate model within a global climate model, 2) developing simple regression relationships between the needed fine scale variables and the global climate model (similar to so-called model output statistics routinely generated from numerical weather prediction output), and 3) developing more complex relationships, sometimes based upon diagnostic constraints, between the needed fine scale variables and the global climate model output. In each of these categories, the routine production of observations of the complete energy, water, and carbon cycles will play a critical role.

Thus, we believe that an initial strategy for integrating routine climate observations with models in a climate service should include three major thrust areas. These areas are: 1) routine production of a suite of CDRs that can be used to fully describe the water, energy, and carbon cycles, 2) understanding, assessing, and improving climate model's water, energy and carbon cycles at global and regional-scale's, and 3) using the improved observations and models to provide trustworthy regional and finer scale state variables, such as surface temperature and precipitation, that form the primary use of climate information by the application community.

6. Conclusions

Major progress has been made to restore the continuity of observations for essential climate variables originally lost as part of the Nunn-McCurdy certification that rescaled the NPOESS program. In addition, the U.S. has started a National effort to routinely produce trustworthy CDRs from the past, current, and future generations of operational environmental satellite data. Parallel with that effort, an international effort has also begun to ensure sustained and coordinated observation, intercalibration, and processing of environmental satellite observations on the international level. Taken together, these developments form the basis for a robust and sustained observing and stewardship system for critical climate observations for the next several decades.