

**Briefing Notes on
NASA-NOAA Joint Document
Impacts of NPOESS Nunn-McCurdy Certification on Joint NASA-NOAA Climate Goals
(December 11, 2006)**

The following is quoted or paraphrased from the text of the report, with some combining and rearranging of material from the Executive Summary and the main body and appendices of the report.

Background

From the Executive Summary, pp. 4-5:

Detecting climate change, understanding the associated shifts in specific climate processes, and then projecting the impacts of these changes on the Earth system requires a comprehensive set of consistent measurements made over many decades. Many climate trends are small and require careful analysis of long time series of sufficient length, consistency, and continuity to distinguish between the natural long-term climate variability and any small, persistent climate changes. *Interruptions in the climate data records make the resolution of small differences uncertain or even impossible to detect.* To confidently detect small climate shifts requires instrument accuracy and stability better than is generally required for weather research and most other scientific uses. For more than thirty years, NASA research-driven missions, such as the EOS, have pioneered remote sensing observations of the Earth's climate, including parameters such as solar irradiance, the Earth's radiation budget, ozone vertical profiles, and sea surface height. Maintaining these measurements in an operational environment provides the best opportunity for maintaining the long-term, consistent, and continuous data records needed to understand, monitor, and predict climate variability and change.

NPOESS was created by Presidential Decision Directive/NSTC-2 of May 5, 1994 wherein the military and civil meteorological programs were merged into a single program. Within NPOESS, NOAA is responsible for satellite operations, the Department of Defense (DoD) is responsible for major acquisitions, and NASA is responsible for the development and infusion of new technologies. The history of the NPOESS Program and the path to the Nunn-McCurdy violation are provided in Appendix A.

To continue climate-quality measurements beyond the first series of EOS satellites, NASA and the NPOESS Integrated Program Office (IPO) entered into an understanding in 1999 to develop the NPOESS Preparatory Project (NPP) – a satellite mission to bridge a potential climate data gap between the existing EOS and the beginning of the future NPOESS. This understanding assumed that the NPOESS system would continue the mature EOS measurements in an operational environment, many of which addressed the nation's climate monitoring needs. **For NASA, NPOESS was not only a converged civilian and military weather observing system but also the cornerstone of the nation's future climate research program. For NOAA, NPOESS represented a key component of its operational climate observing program and a cornerstone of its Climate Goal.**

NPOESS, as originally configured, would have represented a significant step forward in the nation's ability to deploy a comprehensive climate observing system. Many key climate variables would be measured for decades. The revised Interagency Operational Requirements Document (IORD-2) defined the requirements for the NPOESS geophysical products, or Environmental Data Records (EDRs), which represented a more expansive calibration/validation program than was in place for the Polar Operational Environmental Satellites (POES). In the context of an overall climate observing system, the original NPOESS was an enormous advance over the existing operational systems of POES and the Defense Meteorological Satellite Program (DMSP), and it sustained many of the new capabilities demonstrated by NASA research missions. [emphasis added]

[In December 2005, the NPOESS System Program Director notified Congress that cost estimates for the program had increased from \$6.5 billion to \$10 billion and the scheduled launch of its first satellite had slipped from May 2006 to at least April 2008. This breach of the original cost estimate by more than 25% triggered a requirement for a six-month Pentagon review triggered by the Nunn-McCurdy Act.]

NASA-NOAA report, p. 67:

During the Nunn-McCurdy process, ground rules endorsed by the NPOESS Executive Committee (EXCOM) stipulated that a higher priority would be placed on the continuity of operational capabilities in support of weather measurements, which resulted in a lower 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 re-scoping of NPOESS as a result of the Nunn-McCurdy Certification process reduced the total number of planned satellites to be flown from six to four, delayed the originally scheduled launch of each of the satellites by several years, and either completely eliminated (“de-manifested”) or reduced the coverage or capability of eight sensors that were intended to make up the essential core of the future global climate observing system.]

Executive Summary, pp. 5-6:

The loss of climate sensors due to the NPOESS Nunn-McCurdy Certification places the overall climate program in serious jeopardy. These shortfalls are characterized in a recent letter from the Chair of the Joint Science Committee from the World Climate Research Programme (WCRP) and from the Chair of the Steering Committee from the Global Climate Observing System (GCOS) to the Chair of the Committee on Earth Observation Satellites (CEOS). **The Chairs from WCRP and GCOS state, “Some of the difficulties in establishing and maintaining climate observations from space are currently being highlighted by the de-scoping of NPOESS, in which climate observations have been seriously compromised.”** They add, **“...unless revised plans compensate for the anticipated shortcomings in climate observations, gaps in several key climate data records (some that go back almost 30 years) are highly likely.”** They further state, **“WCRP and GCOS assert**

that our ability to address critical climate issues, with profound societal implications, will be strongly limited unless observation of climate variables is given higher priority. We urge that this be done.”

The Nunn-McCurdy Certification defines four possible dispositions for the original sensors:

1. De-manifested: sensor flown only if developed outside of NPOESS program
2. Reduced Coverage: sensor flown on one less flight per day (i.e., one less orbit)
3. Reduced Capability: sensor to be redesigned at lower cost and less capability
4. No Change: sensor is built and flown as specified before certification.

Executive Summary, p. 4:

This report describes the impacts of the Nunn-McCurdy Certification of the National Polar-orbiting Operational Environmental Satellite System (NPOESS) on the climate program goals of the National Aeronautics and Space Administration (NASA) and the National Oceanic and Atmospheric Administration (NOAA). It was developed at the direction of the Office of Science and Technology Policy (OSTP) as a result of a meeting on June 26, 2006. The report contains joint NASA-NOAA recommendations as to how the impacted climate-related observations and related science might be recovered.

This document narrowly focuses on the impacts of the NPOESS Nunn-McCurdy Certification on two climate-related objectives within the context of the U.S. Climate Change Science Program (CCSP). These two objectives are: (1) to fly critical climate sensors that had been planned for NPOESS which represent the continuation of NASA’s Earth Observing System (EOS) capabilities, and (2) to fly those sensors that represent a fundamental contribution to NOAA’s Climate Mission, which includes both heritage satellite and in-situ observing systems....

The National Academy of Sciences is also developing a companion study addressing the loss of the climate sensors due to the NPOESS Nunn-McCurdy Certification that will be completed in July 2007. The Decadal Survey and the companion study as well as other available information will form the foundation of a NASA/NOAA mission roadmap to be completed later in the summer of 2007.

Impacts of Nunn-McCurdy Certification on NPOESS Climate Sensors

The NASA-NOAA report concludes (p.64):

The Nunn-McCurdy Certification will significantly decrease our ability to detect climate variability versus change and our ability to understand the causes of change. The Nunn-McCurdy Certification results in the termination of critical data records and causes a number of climate data gaps. In coping with this situation, scientists need to rely on a variety of alternative and usually inferior data sets to extend and provide the missing data. In many cases, the procedures necessary to use alternative data require extraordinary efforts, especially in those cases where the alternative data are very different in character

and/or quality from the data they are replacing. In spite of these efforts, the resulting data sets will have greater uncertainty than would be available from a continuous, homogeneous data set, and also have the potential to introduce larger errors into the interpretation of climate variability and change.

From Executive Summary and sections on individual sensors:

De-Manifested Sensors

Total Solar Irradiance Sensor (TSIS)

Earth Radiation Budget Sensor

Ocean Altimeter (ALT)

Ozone Mapping and Profiler Suite (OMPS) Limb Instrument

Aerosol Polarimetry Sensor (APS)

Reduced Capability and Reduced Coverage

Conical Microwave Imaging Scanner (CMIS)

Visible Infrared Imaging Radiometer Suite (VIIRS)

Cross-track Infrared Sounder (CrIS) used in conjunction with the Advanced Technology

Microwave Sounder (ATMS)

Summary of the impacts of eliminating the three climate sensors identified as highest priority in the NASA-NOAA report

1. Total Solar Irradiance Sensor (TSIS), a *de-manifested sensor*:

Background: The sun is the only significant external source of energy to the Earth system. Thus, Total Solar Irradiance (TSI) has a major impact on Earth's average temperature. Furthermore, solar radiation is the dominant, direct energy input into terrestrial ecosystems and, thus, it affects all physical, chemical, and biological processes – many of which impact human health and well being. *Precise observations of the total solar output are therefore essential to determine the influence of natural variability in climate and climate change.*

Science Impact: *These measurements monitor the energy of the sun incident on Earth. They are crucial measurements that can be accurately determined only above the atmosphere. Any interruption of the 28-year data record of Total Solar Irradiance jeopardizes our ability to confidently resolve small changes in this most fundamental variable.*

Societal applications and impacts: Precise, long-term observations of the total energy output by the sun are required to identify and isolate natural solar variations that impact climate in contrast to other factors, such as human influences on climate. Long-term records are needed to capture multiple instances of the 11-year solar cycle.

The spectral dependence of solar output is also required to determine changes in ultraviolet solar output which affects stratospheric temperature, structure, composition, and dynamics. These effects impact long-term climate predictions, particularly ozone and human health.

Without TSIS, we cannot definitively discriminate and quantify natural versus anthropogenic drivers of climate change. Further, we cannot assess how solar variability is affecting different components of the Earth system. This represents an irrevocable end of a 30-year TSI record. Spectral measurements stop at end of SORCE mission after ~ 9 years.

2. Earth Radiation Budget Sensor (ERBS), a de-manifested sensor:

Essential Climate Variables: Net shortwave and longwave radiation at the top of the atmosphere.

Background: *Along with incoming solar radiation, outgoing radiation helps establish the Earth's radiant energy balance; the difference between the two corresponds to "climate forcing", which is exhibited in part by rising global average tropospheric temperatures.*

The radiant energy from the sun provides the energy that maintains climate. Approximately two thirds of the solar radiant energy incident on the Earth is absorbed, heating it until it radiates as much energy back to space as it absorbs from the sun. The remaining one third of the incident solar energy is reflected back into space. Both the absorbed and reflected solar radiation are in the shortwave part of the electromagnetic spectrum (mostly visible light), while the Earth's radiation emitted back to space is longwave or thermal infrared radiation. The balance between the solar input and the thermal output is known as the Earth's radiation budget. The radiation budget is most affected by the nature of the Earth's surface and its atmosphere including clouds.

While NASA's Earth Radiation Budget Experiment observationally demonstrated that clouds act to cool the current climate, the impact of clouds on the radiation budget as the climate responds to natural and anthropogenic forcing remains one of the largest uncertainties in climate science.

Science Impact: *This measurement monitors the energy that maintains climate and it can be accurately determined only above the atmosphere. Accurate Earth radiation budget observations can only be made from space.* They were the first Earth scientific observations ever from space in 1960 and ongoing observations have been made for over 20 years. Persistent climate changes are small and difficult to detect within the diurnal, regional, and seasonal variance of the reflected shortwave and emitted longwave energy. *To identify and study these changes requires measurements of high accuracy and precision extending over a time period of at least 30 years based on systematic sampling studies.* Overlap among space-based sensors is critical to confidently detect and monitor the small changes in the Earth's radiation balance capable of affecting climate.

Societal applications and impacts: The Earth-atmosphere system equilibrium temperature is determined by the balance between the incoming solar radiation, the amount of that incoming radiation reflected back to space by the Earth's surface and clouds, and the longwave Earth emitted radiation. The Earth's emitted radiation is regulated by clouds and greenhouse gases. *Accurate observations of the Earth's radiation are essential to accurately determine the causes of climate change and important internal climate feedback effects, which over decades can substantially alter climate.*

3. OCEAN Altimeter (ALT), a de-manifested sensor:

Essential Climate Variables: Sea level height, regional ocean currents, basin-scale variability such as El Niño.

Background: The Earth's oceans, covering 70% of its surface, exert great influence on global climate. **Only from space can we observe our vast oceans on a global scale and monitor critical changes in them.** Continuous ocean dynamic height data from satellites like TOPEX/Poseidon and JASON help us understand the effects of the changing oceans on our climate and on significant cyclical climate events such as El Niño and La Niña. The Earth's oceans are a major sink for solar energy. The oceans transport this solar energy as heat through ocean currents and release it back into the atmosphere as water vapor and sensible heat, which is then returned back to the oceans and land as heat and precipitation. This is a major part of the water and energy cycles. In addition, global climate variability (El Niño and La Niña, the Pacific Decadal Oscillation and the North Atlantic Oscillation) affects regional ocean circulation patterns, which transport heat and other materials and change regional climate, fisheries, water quality, CO₂ uptake, etc. **Global warming is increasing sea level height through both increases in ocean volume (warming effects) and the addition of water to the oceans due to the melting ice sheets.**

Societal applications and impacts: Ocean topographical data are vital to study the role of ocean circulation and the associated thermal transport in the climate system, sea level rise, assessing the severity of hurricanes, tracking coastal ocean currents, and aiding in the forecasting of natural disasters. **Sea level measurements are the climate change indicators of most direct concern for a substantial proportion of the U.S. and the world's population, most of whom live near the coast.**

Satellite altimeters are the only means to monitor spatially continuous fields of changes in global and regional sea level, as well as basin-scale and regional ocean circulations. Sea level rise is of growing concern in the coastal zone and

Air-sea interactions are responsible for persistent climate flood and drought anomalies such as El Niño and the Pacific Decadal Oscillation. Altimeter data are required for initializing and validating seasonal to interannual climate forecast models. **Without ALT, we cannot comprehensively assess and predict rates of ocean expansion due to ice-melt and temperature change.** Continued ocean expansion will likely inundate some coastal areas. **Furthermore, we cannot adequately assess ocean storm intensification.**

NPOESS Certified Program: No Altimeter is planned

Summary of impacts of other de-manifested, reduced capability, and reduced coverage sensors

4. Ozone Mapping and Profiler Suite Limb Subsystem (OMPS-Limb), a de-manifested sensor:

Science Impact: Stratospheric ozone absorbs incoming solar ultraviolet radiation that can be harmful to humans and other organisms. Anthropogenic emissions of halogen-containing gases (e.g. Freon) are now known to destroy stratospheric ozone. The Montreal Protocol on Substances Depleting the Ozone Layer has resulted in successful international actions to reduce atmospheric concentrations of halogen-containing gases. The continuation of stratospheric ozone observations is crucial to monitor and evaluate the recovery of the ozone layer.

[Note: NOAA Administrator Lautenbacher indicated in congressional testimony on March 22 an intention to add funds to the NOAA FY2008 budget to restore work on the ozone mapping sensor.]

5. **Conical Scanning Microwave Imager (CMIS)** a reduced sensor capability:

Science Impact: Microwave observations from satellites have allowed sea surface temperatures, sea ice and snow cover extents, vegetation, ocean surface wind speed, water vapor, precipitation rates, and other surface variables to be analyzed even in the presence of heavy cloud cover and have consequently made microwave radiometers particularly applicable for climate studies.

6. **Aerosol Polarimetry Sensor (APS)**, a de-manifested sensor:

Science Impact: Aerosol properties are a high priority in the U.S. Climate Change Science Program. The effects of aerosols on global temperature are significant and may be comparable in importance to the role played by “greenhouse” gases, such as carbon dioxide and methane, which contribute to the warming of the Earth’s surface.

7. **Visible Infrared Imaging Radiometer Suite (VIIRS)**, a reduced coverage sensor:

Science Impact: VIIRS is a moderate resolution, wide swath, multispectral radiometer covering the visible to thermal infrared spectral range. For more than three decades, scientists have depended on such imagery for a wide variety of societal applications, including weather and climate analysis, monitoring agriculture, and disaster prediction and assessment.

8. **Cross-track Infrared Sounder (CrIS)**, a reduced coverage sensor:

Science Impact: The CrIS is designed to work with the ATMS to produce daily vertical profiles of atmospheric temperature and moisture.