NASA

National Aeronautics and Space Administration

Office of Inspector General

Office of Audits

NASA's Management of Distributed Active Archive Centers

March 3, 2020

Report No. IG-20-011

Office of Inspector General

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Results in Brief

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March 3, 2020 IG-20-011 (A-19-002-00)

Why We Performed This Audit

For more than 50 years, NASA has launched satellites and other scientific instruments into space to observe the Earth and collect data on climate, weather, and natural phenomena such as earthquakes, droughts, floods, and wildfires. The data generated by the Agency's Earth science missions is stored at 12 Distributed Active Archive Centers (DAAC). Located at NASA Centers, universities, and other federal agencies, DAACs are responsible for processing, archiving, and distributing data. Over the next 6 years, the volume of Earth observation data the Agency will need to archive is expected to increase from 32 petabytes to 247 petabytes (1 petabyte of storage is the equivalent of 1.5 million CD-ROM discs) when several high-data-volume missions, such as the NASA-Indian Space Research Organization Synthetic Aperture Radar (NISAR) and the Surface Water and Ocean Topography (SWOT), come online.

In 2014, the Earth Science Data and Information System (ESDIS) project within the Science Mission Directorate, sponsored an independent review to study potential efficiencies and enhanced capabilities, including cloud computing, open source software, and tool/service interoperability, across the DAACs. As a result of this review, ESDIS is proceeding with the Earthdata Cloud storage initiative, which will enable end users to work across multiple large data sets managed by different DAACs without the need to transmit data thereby streamlining data distribution. NASA has chosen Amazon Web Services as the Agency's provider for general-purpose cloud services and the operating environment for Earthdata Cloud.

To assess NASA's management of the DAACs and ESDIS data management and cloud transition efforts, we evaluated: (1) the challenges ESDIS faces in transitioning Earth observation data from the DAACs to the cloud and any efficiencies realized by this transition, (2) the extent to which appropriate NASA entities are being consulted on the Agency's data management requirements, (3) the extent to which ESDIS appropriately addressed data integrity risks, and (4) the extent to which NASA complied with senior agency official recommendations and decisions for the DAACs. To gain an understanding of how the DAACs are managed and ESDIS's cloud transition efforts, we performed work at several NASA Centers and DAAC locations, interviewed NASA officials and DAAC managers, and reviewed federal and NASA policies, procedures, and documentation.

What We Found

NASA expects the volume of Earth observation data stored in the cloud to exponentially increase due to several upcoming high-data-volume missions, including NISAR and SWOT. Such dramatic increases in the overall size of the DAAC archive through 2025 presents multiple challenges to NASA. Specifically, the Agency faces the possibility of substantial cost increases for data egress (i.e., when end users download data from a network to an external location) from the cloud. Currently, when end users access and egress data through a DAAC there is no additional cost to NASA other than maintaining the current infrastructure. However, when end users download data from Earthdata Cloud, the Agency, not the user, will be charged every time data is egressed. Ultimately, ESDIS will be responsible for both cloud costs, including egress charges, and the costs to operate the 12 DAACS. In addition, ESDIS has not yet determined which data sets will transition to Earthdata Cloud nor has it developed cost models based on operational experience and metrics for usage and egress. As a result, current cost projections may be lower than what will actually be necessary to cover future expenses and cloud adoption may become more expensive and difficult to manage. Collectively, this presents potential risks that scientific data may become less available to end users if NASA imposes limitations on the amount of data egress for cost control reasons.

NASA requirements do not detail specific direction for organizations to coordinate with ESDIS and the Agency's Office of the Chief Information Officer (OCIO) when creating data management plans that detail the types and amount of data to be collected, processed, and stored. Although NASA guidance directs the development of data management plans, this does not include a requirement for programs to consult ESDIS or the OCIO. As a result, ESDIS or the OCIO may not know about or have sufficient input into the amounts, types, and structure of data to be ingested, processed, and archived. When missions fail to consult ESDIS when developing their data management plans, they increase the risk of schedule delays, poor data quality, or expensive redesign by the missions or the DAACs.

While DAAC security plans generally followed NASA and National Institute of Standards and Technology (NIST) requirements, ESDIS deviated from the NIST-recommended "moderate" impact level for data integrity. When conducting its security assessment, ESDIS assesses a DAAC's impact level based on its ability to reprocess data in the event it was improperly modified or destroyed rather than on the overall value of the DAAC and its underlying data. In addition, ESDIS excluded critical information types when conducting impact determinations. This occurred because ESDIS misinterpreted NASA and NIST categorization guidance due to a lack of close OCIO involvement. To help ensure data processed by a DAAC is adequately protected, NIST provides guidance for system categorization, including a library of information types with recommended impact levels to determine whether a system should operate at a low, moderate, or high impact level. Failure to appropriately categorize systems and data can result in inadequate controls for protecting the confidentiality, integrity, and availability of the system and or its data.

Finally, the Evolution, Enhancement, and Efficiency (E&E) panel selected by the Mission Support Council (MSC) to perform an independent review of the DAACs did not attempt to identify potential cost savings. In July 2014, NASA's Capability Steering Committee provided MSC options regarding the future of the DAACs, including recommendations to identify costs savings to be reinvested in a future Earth science mission. However, MSC changed the Capability Steering Committee recommendation to exclude a 20 percent savings target and the E&E panel was not directed by the Earth Science Data System program to identify and quantify specific goals for cost savings. Additionally, 6 of 12 E&E panel members were not independent because they were not external to the Earth Science Data System program, which may have affected the findings and recommendations of the review.

What We Recommended

In order to mitigate the risks associated with the migration to the cloud, improve data management planning, and enhance system security categorizations, we made the following recommendations to NASA's Associate Administrator for the Science Mission Directorate: (1) once NISAR and SWOT are operational and providing sufficient data, complete an independent analysis to determine the long-term financial sustainability of supporting the cloud migration and operation while also maintaining the current DAAC footprint; (2) incorporate in appropriate Agency guidance language specifying coordination with ESDIS and OCIO early in a mission's life cycle during data management plan development; and (3) ensure all applicable information types are considered during DAAC categorization, that appropriate premises are used when determining impact levels, and that the appropriate categorization procedures are standardized. We provided a draft of this report to NASA management who concurred with our recommendations and described planned actions to address them. We consider management's comments responsive; therefore, the recommendations are resolved and will be closed upon verification and completion of the proposed corrective actions.

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TABLE OF CONTENTS

Acronyms

AWS	Amazon Web Services
CSC	Capability Steering Committee
DAAC	Distributed Active Archive Center
E&E	Evolution, Enhancement, and Efficiency
EOSDIS	Earth Observing System Data and Information System
ESDIS	Earth Science Data and Information System
ESDS	Earth Science Data Systems
FedRAMP	Federal Risk and Authorization Management Program
FY	fiscal year
MOPITT	Measurement of Pollution in the Troposphere
MSC	Mission Support Council
NISAR	NASA-ISRO Synthetic Aperture Radar
NIST	National Institute of Standards and Technology
NPD	NASA Policy Directive
NPR	NASA Procedural Requirement
NRC	National Research Council
NSIDC	National Snow and Ice Data Center
OCIO	Office of the Chief Information Officer
OIG	Office of Inspector General
OMB	Office of Management and Budget
SIPS	Science Investigator-led Processing System
SWOT	Surface Water and Topography
TCAT	Technical Capabilities Assessment Team

INTRODUCTION

For more than 50 years, NASA has launched satellites and other scientific instruments into space to observe Earth and collect data on climate, weather, and natural phenomena such as earthquakes, droughts, floods, and wildfires. This Earth observation data provides private citizens, commercial entities, and government and military organizations information to prepare for and react to weather phenomena and natural disasters, manage agricultural and other natural resources, and operate transportation systems, among other things.

The data generated by NASA's Earth-observing satellites and field measurement programs for the Agency's Earth science missions is stored at 12 Distributed Active Archive Centers (DAAC) located at NASA Centers, universities, and other federal agencies.[1] Over the next 6 years, the volume of Earth observation data the Agency will need to archive is expected to increase from approximately 32 petabytes of data to approximately 247 petabytes when several high-data-volume missions, such as the NASA-Indian Space Research Organization Synthetic Aperture Radar (NISAR) and the Surface Water and Ocean Topography (SWOT), come online.[2] In 2014, as the result of a Technical Capabilities Assessment Team initiative, the NASA Capability Steering Committee (CSC) recommended that the Earth Science Data and Information System (ESDIS) project sponsor an independent review to study both potential efficiencies and enhanced capabilities, including cloud computing, open source software, and tool/service interoperability, across the DAACs.[3] As a result of this review, ESDIS is proceeding with cloud storage alternatives for several forthcoming high-data-volume missions, including NISAR and SWOT, instead of the more traditional DAAC storage.

To assess NASA's management of the DAACs and ESDIS data management and cloud transition efforts, we evaluated: (1) the challenges ESDIS faces in transitioning Earth observation data from the DAACs to the cloud and any efficiencies realized by this transition, (2) the extent to which appropriate parties are being consulted on the Agency's data management requirements, (3) the extent to which ESDIS appropriately addressed data integrity risks, and (4) the extent to which NASA complied with CSC recommendations and Mission Support Council decisions for the DAACs. See Appendix A for details of the audit's scope and methodology.

[1] A field measurement program is an observational study planned for a specific location and a defined time period during which measurements are conducted from airborne platforms or ground sites to study physical and chemical processes in the atmosphere.

[2] One petabyte is equal to 1,024 terabytes or 1 million gigabytes. Storing a single petabyte would require 1.5 million CD-ROM discs or 20 million 4-drawer filling cabinets. The NISAR satellite is designed to observe and take measurements of some of Earth's most complex processes, including ecosystem disturbances, ice-sheet collapse, and natural hazards such as earthquakes, tsunamis, volcanoes and landslides. NISAR is a joint mission between NASA and the Indian Space Research Organization. SWOT is a satellite mission that will make the first global survey of Earth's surface water, observe the fine details of the ocean's surface topography, and measure how water bodies change over time. SWOT is being jointly developed by NASA and the French government space agency with contributions from the Canadian Space Agency and United Kingdom Space Agency.

[3] For the purposes of this report, when we use the term "cloud" we are referring to a commercial cloud provided by a private vendor, not an "internal cloud," "private cloud," or other highly virtualized environment.

Background

Earth Science Data and Information System Organization

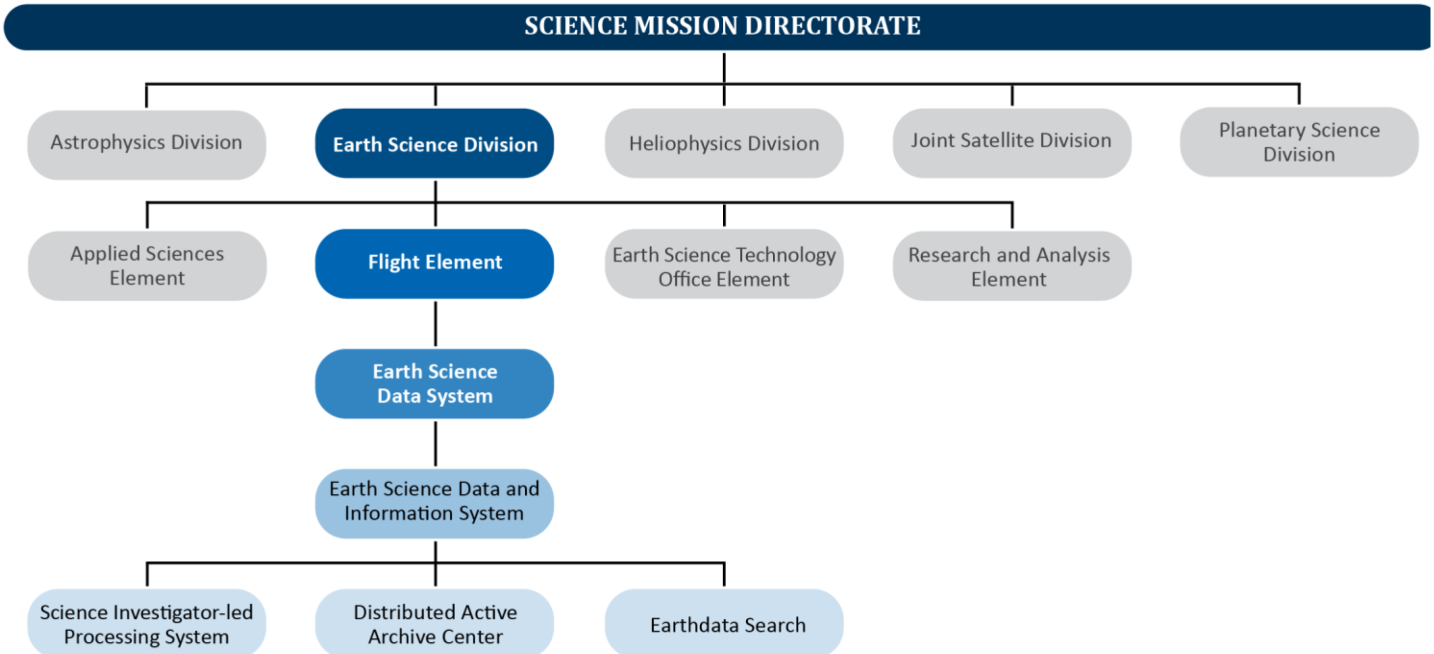
NASA's Science Mission Directorate develops and deploys satellites and probes in collaboration with NASA's partners around the world to answer fundamental questions requiring the view from and into space. The Directorate consists of five divisions: Astrophysics, Earth Science, Heliophysics, Joint Agency Satellite, and Planetary Science. The Earth Science Division conducts missions that help NASA understand Earth's systems, such as water and energy cycles, surface and interior, and atmospheric composition. The Agency's Earth science efforts encompass a variety of research categories, including weather, climate change, and ice sheet monitoring. The Earth Science Division is organized into four program elements: Applied Sciences, Earth Science Technology Office, Flight, and Research and Analysis.

The Earth Science Data System (ESDS) program, which aligns under the Flight element, is an essential component of the Earth Science Division. The ESDS program is responsible for managing NASA's Earth science data; developing data system capabilities to support science investigations and research; processing instrument data to create long-term Earth science data records; upholding NASA's policy of full and open sharing of all data, tools, and ancillary information for end users; and engaging members of the Earth science community in the evolution of data systems. The ESDIS project, which aligns under the ESDS program, is responsible for

- processing, archiving, and distributing Earth science data;
- providing tools to facilitate the processing, archiving, and distribution of Earth science data;
- collecting metrics and end-user satisfaction data to learn how to continue improving services provided to end users; and
- ensuring scientists and the public have access to data to enable the study of the Earth from space to advance Earth system science to meet the challenges of climate and environmental change.

ESDIS also maintains the Earth Observing System Data and Information System (EOSDIS), a data and information system to support multidisciplinary research in Earth science and public data. EOSDIS includes the DAACs, Science Investigator-led Processing Systems (SIPS), and many data tools and services such as the Earthdata Search website. Figure 1 shows the organizational structure of ESDS.

Figure 1: Earth Science Data System Program Structure



Source: NASA Office of Inspector General (OIG) presentation of ESDIS information.

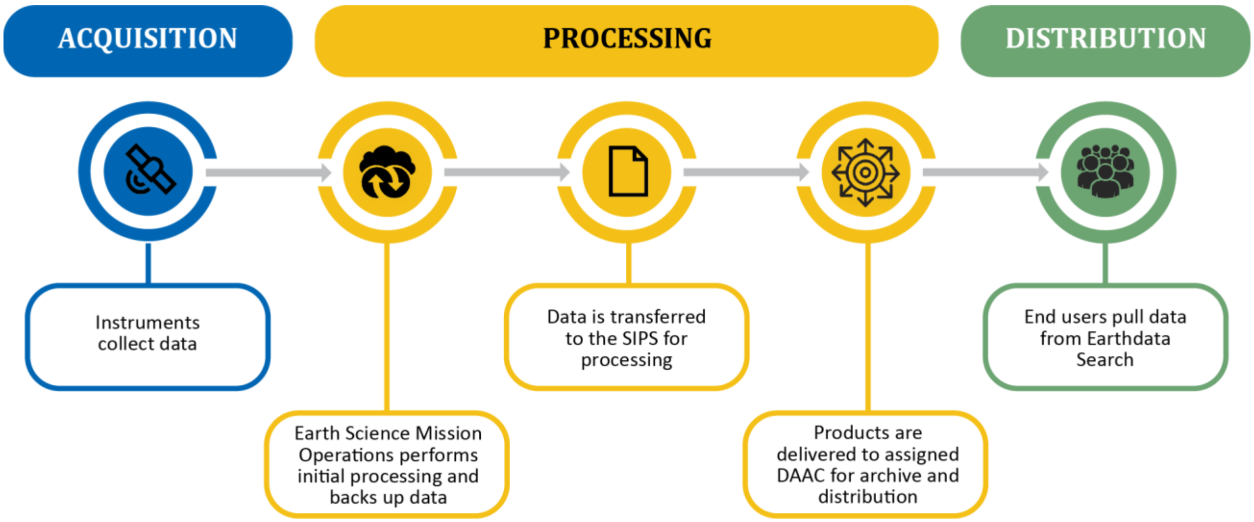
Role and Function of Earth Observing System Data and Information System Operations

EOSDIS is designed as a distributed system housing data at 12 DAACs located throughout the United States. DAACs ingest, archive, and distribute data from NASA's past and current Earth-observing satellites, select international partner satellites, airborne investigations, and field measurement campaigns. For many missions assigned to ESDIS, the Earth Science Mission Operations project acquires data from various scientific instruments, performs initial processing, and completes a backup archive of the data.[4] Next, the data is transferred over NASA networks to a SIPS for processing and conversion of the raw data into a usable format for end users. The DAACs then archive and make data publicly available to end users—such as private citizens, commercial entities, and government and military organizations—via tools such as Earthdata Search, a web application that helps users discover, visualize, refine, and access Earth observation data made available by NASA and other government and international partners.[5] Figure 2 shows the flow of Earth science data from the collection instrument to the end user.

[4] The Earth Science Mission Operations project, located at Goddard Space Flight Center, is responsible for spacecraft maintenance and operations for Earth science missions conducted by the Earth Science Projects Division at the Center.

[5] Earthdata Search is the primary website for access to all NASA's Earth science data located within DAACs. Core services include the Common Metadata Repository, which provides a single source of Earth science metadata with an ingest and search architecture for submission and discovery of all EOSDIS data sets. In fiscal year 2018, approximately 660,000 unique visitors accessed the Earthdata Search website viewing approximately 9.8 million pages of information. See: https://search.earthdata.nasa.gov/search (last accessed February 25, 2020).

Figure 2: Earth Science Data Flow



Source: NASA OIG analysis of ESDIS information.

Products produced at the SIPSs are then sent to a designated DAAC for archive and distribution. NASA's 12 DAACs ingest, archive, and distribute data, and each DAAC specializes in a particular science discipline. When EOSDIS was first developed, only two DAACs existed. At the urging of the Earth science community, NASA increased the number of DAACs to 8 in the early 1990s and later to 12 in 2013. Between 1991 and 2008, ESDIS implemented major information technology architectural changes, and in 1998 moved from a centralized system to a federated system, which included SIPS.[6]

Each DAAC has servers and hardware run by contractor and in some instances also run by NASA civil servant staff. The DAACs are located at not only NASA facilities but also non-NASA facilities, including other federal agencies such as the United States Geological Survey and the Department of Energy and universities such as Columbia University and the University of Colorado Boulder. The Earth Science Division assigns new missions or data sets to DAACs based on scientific discipline and field campaign. Different Earth science end users place unique demands on how data are processed, formatted, projected, and used; as such, DAAC systems are optimized for the types of data they support. Once the data has been processed, it is then made available by the DAAC to end users, at no charge, through Earthdata Search. The DAACs also provide end user services, including assistance in selecting and obtaining data, access to data-handling and visualization tools, notification of data-related news, and technical support and referrals.

The Earth Science Division selects principal investigators/team leaders, forms science teams, and conducts scientific peer reviews of the specifications for standard geophysical products, including metadata, from instrument observations.[7] The resulting products are produced under the direct control of principal investigators/team leaders. ESDIS supports data processing by providing SIPSs for use by the

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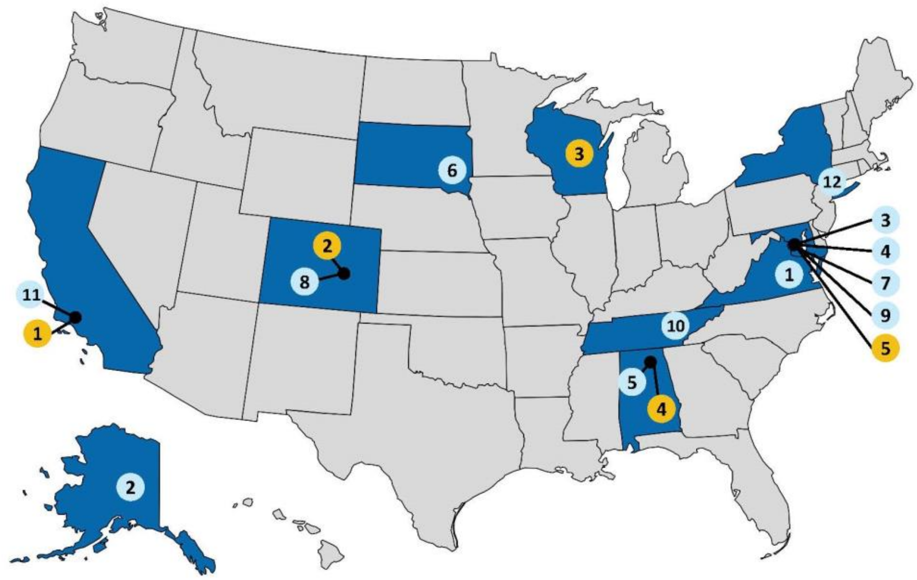
6 In a federated system, individual source systems maintain control over their own data but agree to share some or all of this information with other participating systems upon request. System users submit queries via a shared intermediary interface that then searches the independent source systems.

7 Geophysical products are products related to the physics of Earth such as the movement of the planet's crust and the temperature of its interior. Metadata is a set of data that describes and gives information about other data, acting as a "card catalog" for a library of data.

principal investigators/team leaders. The SIPSs are geographically distributed across the United States, and while there are six physical SIPS centers, one location can have multiple SIPSs. Figure 3 shows the location of both the DAACs and the SIPSs. For additional details on the scientific disciplines of each DAAC, see Appendix B.

Figure 3: DAAC and SIPS Locations



DAACs

1. Atmospheric Sciences Data Center (ASDC), Langley Research Center
2. Alaska Satellite Facility (ASF), Geophysical Institute of the University of Alaska
3. Crustal Dynamics Data Information System (CDDIS), Goddard Space Flight Center
4. Goddard Earth Science Data and Information Services Center (GES DISC), Goddard Space Flight Center
5. Global Hydrology Research Center (GHRC), Marshall Space Flight Center and University of Alabama
6. Land Processes (LP), USGS Earth Resources Observation Science Center
7. MODIS/VIIRS Level 1 and Atmosphere Data System (LAADS), Goddard Space Flight Center
8. National Snow and Ice Data Center (NSIDC), Cooperative Institute for Research in Environmental Sciences
9. Ocean Biology (OB), Goddard Space Flight Center
10. Oak Ridge National Laboratory (ORNL), Department of Energy
11. Physical Oceanography (PO), Jet Propulsion Laboratory
12. Socioeconomic (SEDAC), Center for International Earth Science Information Network

SIPSs

1. MLS, TES, and SNPP Sounder, Jet Propulsion Laboratory
2. MOPITT, University of Colorado Boulder
3. SNPP Atmosphere, University of Wisconsin
4. AMSR-U and LIS,GHRC
5. SNPP, MODIS, OMI, and OOBPG, Goddard Space Flight Center

Source: NASA OIG analysis of ESDIS information.

Federal Data Requirements

Federal mandates require government agencies to conduct open sharing of data with the public, manage that data efficiently, and transition data services to the cloud.[8]

Data Management

The Office of Management and Budget (OMB) has established guidance to help federal agencies manage federal information and information technology resources.[9] OMB Circular A-130 requires the free flow of information from the government to the public and emphasizes the government's intent to minimize costs to the public. The circular also deems an agency's Chief Information Officer ultimately responsible for the agency's data storing and open-sharing requirement needs. Additionally, OMB Memorandum M-13-13 requires federal agencies to collect or create information in a way that supports subsequent information processing and dissemination activities.[10] The memorandum states that management of information resources must begin at the earliest stages of the planning process, well before information is collected or created. Agencies are encouraged to evaluate current information management processes and identify opportunities for more efficient use of taxpayer dollars and downstream cost savings.

The National Academy of Sciences has recommended early consultation with data stewards and other affected institutional parties early in research planning at NASA.[11] In a 2002 review of the usefulness and availability of NASA'S earth and space science mission data, the National Research Council (NRC)—the research arm of the National Academy of Sciences—noted that advances in scientific understanding also require (1) the ability to collect, share, and save data; (2) the computational power to reduce data and create models; (3) communications to move data from one place to another; (4) structures to manage the data and associated resources; and (5) access to data over extended time periods.[12] As part of this review, the NRC made recommendations to NASA on how the Agency could improve the management of science data. For example, the NRC recommended the Agency establish a dedicated Chief Science Information Officer who would be responsible for managing NASA's science information to include budgetary responsibility for the collection, analysis, and long-term maintenance of all Earth and space science data sets. The review stated that the functions of this position would be separate from those of the Chief Information Officer at NASA, who is primarily responsible for NASA business systems and security.[13] However, NASA did not implement the NRC's recommendation, and the Office of the Chief Information Officer (OCIO) is ultimately responsible for data storing and open sharing as well as managing enterprise cloud services with no distinction between scientific data management and business systems data.

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[8] Office of Management and Budget Circular No. A-130, *Managing Information as a Strategic Resource* (July 18, 2016); Office of Management and Budget Memorandum M-13-13, *Open Data Policy-Managing Information as an Asset* (May 9, 2013); and Office of the U.S. Federal Chief Information Officer, *25 Point Implementation Plan to Reform Federal Information Technology Management* (December 2010).

[9] OMB Circular No. A-130.

[10] M-13-13.

[11] The National Academy of Sciences, in conjunction with the National Academy of Engineering and the National Academy of Medicine, is a private, nonprofit organization of the country's leading researchers providing objective, science-based advice on critical issues affecting the nation.

[12] NRC, *Assessment of the Usefulness and Availability of NASA'S Earth and Space Science Mission Data* (2002). The NRC is the research arm of the National Academies of Sciences, Engineering, and Medicine, which produces reports that shape policies, inform public opinion, and advance the pursuit of science, engineering, and medicine.

[13] OMB Circular No. A-130.

Cloud Computing

Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of resources, such as computer services, storage, software applications, and web services, that can be provided with minimal management effort or service provider interaction.[14] To accelerate the federal government's use of cloud computing, in 2010, OMB required agencies to adopt a "Cloud First" policy when contemplating information technology purchases and to evaluate secure, reliable, and cost-effective cloud computing alternatives when making new information technology investments.[15] To help federal agencies meet the requirements of Cloud First, the General Services Administration collaborated with the National Institute of Standards and Technology (NIST) and the Departments of Defense and Homeland Security to establish the Federal Risk and Authorization Management Program (FedRAMP). FedRAMP's mission is to promote the adoption of secure cloud services across the federal government by providing a standardized approach to security and risk assessment. Since June 2014, federal agencies have been required to ensure the cloud services they use are FedRAMP-approved.

NASA Cloud Services

A cloud computing system may be deployed privately or hosted on the premises of a cloud customer, shared among a limited number of trusted partners, or hosted by a third party or a publically accessible service. Depending on the kind of cloud deployment, the cloud may have limited private computing resources (networks, servers, storage, applications, and services) or may have access to large quantities of remotely accessed resources. The different deployment models present a number of trade-offs in how customers can control their resources, and the scale, cost, and availability of those resources. A key aspect of a commercial cloud is the vast capacity this type of system provides over an on-premise data storage system such as a DAAC. Compared to on-premise data storage, which requires a larger, upfront capital investment for hardware and installation and further investment any time additional storage is needed, a commercial cloud is less expensive in terms of infrastructure costs and more agile because capacity can easily be expanded. However, managing the risks of transferring to and maintaining systems and data in a cloud environment can be challenging when it is managed and maintained by a third-party provider rather than the agency.

In 2016, the OCIO established the Computing Services Program Office to promulgate the Agency's cloud computing strategy and related standards, and approve, coordinate, and oversee acquisition of cloud computing services intended for Agency-wide use. The OCIO is also designated as the official NASA interface to FedRAMP and commercial cloud providers for Agency business. NASA has chosen Amazon Web Services (AWS) as the Agency's provider for general-purpose cloud services. NASA entered into a 5-year, $65 million task order with AWS in 2018 utilizing a "pay-as-you-go" model, meaning the Agency only pays for services, such as cloud storage and egress, as they are used.[16] According to ESDIS, AWS is currently the only NASA-approved commercial cloud provider, and ESDIS and the DAACs are building and testing prototypes to ensure that EOSDIS data and services will work successfully on the AWS cloud platform.

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[14] National Institute of Standards and Technology (NIST) Special Publication 800-145, *The NIST Definition of Cloud Computing* (September 2011).

[15] Office of the U.S. Federal Chief Information Officer, *25 Point Implementation Plan to Reform Federal Information Technology Management* (December 2010).

[16] Data egress refers to data leaving a network, usually through end user requests, in transit to an external location.

Technical Capabilities Assessment Team

In 2012, NASA established the Technical Capabilities and Assessment Team (TCAT) review to evaluate the technical capabilities required to support the Agency's goals. This assessment was intended to help NASA make informed decisions on investing/divesting strategically within the Agency's budget while strengthening innovation in critical areas needed to advance NASA's mission. The TCAT assessment related to Earth science focused on the disposition of DAAC operations and the distribution of the Earth science network across the Agency.

To further evaluate and analyze information provided by TCAT, NASA established the Capability Steering Committee (CSC). Led by the Agency's Deputy Associate Administrator, CSC was tasked with developing options and actionable recommendations regarding the extent to which technical capabilities should be maintained at various NASA locations.[17] As a result of TCAT and CSC assessments, in 2014, CSC developed a decision package that focused on the distribution and management of Earth science workforce across the Agency and the disposition of cost and management of the DAACs. One option in the decision package was to require ESDS to sponsor an independent review to study potential efficiencies and enhanced capabilities at the DAACs.[18]

The Mission Support Council (MSC) was then responsible for reviewing CSC's decision package and making decisions to address TCAT observations. MSC serves as the Agency's senior decision-making body regarding the integrated Agency mission support portfolio. The scope and authority of MSC encompasses all mission support activities conducted by NASA, including facilities, workforce, information technology, infrastructure, and capability portfolios. NASA leaders are responsible to MSC for implementing decisions made within their authority. MSC reports to NASA's Executive Council, and members include the Deputy Associate Administrator (Chair); Associate Administrator; Associate Administrator for Mission Support; Chief Financial Officer; Chief Information Officer; and Chief, Safety and Mission Assurance.[19]

EOSDIS Cloud Transition Initiative

In fiscal year (FY) 2019, EOSDIS had a cumulative archive size of 32 petabytes of data stored at the DAACs with this volume projected to grow to 247 petabytes by FY 2025. Since May 2018, 5 Earth science missions have launched, and an additional 10 missions, including NISAR and SWOT, are expected to launch by 2021. In total, all 15 missions will produce an estimated 116 terabytes of data per day. To prepare for this tremendous growth and efficiently provide access to these data, in 2016, ESDIS began an EOSDIS system evolution aimed at developing and deploying a cloud-based architecture to enable the archival and dissemination of EOSDIS data collections from a commercial cloud environment. One of the benefits of such a platform is the assurance of redundant, on-demand network access to a shared pool of computing resources that can be rapidly provisioned to increase capacity as more data is collected and stored.

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[17] NASA transitioned from TCAT to the Capability Leadership Model in April 2015 largely to institutionalize capability management into the Agency's annual planning and budgeting processes. With regard to the various technical capability areas, NASA's Office of the Chief Engineer is responsible for managing the discipline and system capabilities while the research capabilities are divided among the Agency's directorates.

[18] An Evolution, Enhancement, and Efficiency review team, which was to consist of 10 to 12 people external to the ESDIS project and an expert, ad hoc technical group comprised of representatives from ESD, ESDIS Project, DAACs, and the broader EOSDIS community, was subsequently established to conduct the review.

[19] The Executive Council serves as NASA's senior decision-making body, typically addressing decisions affecting the Agency's high-level strategy, organization, governance, budget, and stakeholder management.

Project Cumulus

In August 2017, ESDIS completed a 12-month commercial cloud prototype called EOSDIS Cloud Evolution. The primary goal of this activity was to determine to what extent a commercial cloud environment could be utilized for EOSDIS in the future. As a result of the EOSDIS Cloud Evolution, in 2017, ESDIS developed Project Cumulus, a prototype that will determine how EOSDIS data collections, including those already stored at the DAACs, can be archived and disseminated in a commercial cloud computing environment.

A primary feature of Project Cumulus is a software framework for data ingest, archive, distribution, and management. The overall goal of Project Cumulus is to provide the following functionalities:

- data acquisition from data providers;
- data ingest;
- harvest, creation, and publication of dataset metadata to the Common Metadata Repository;
- storage and distribution of data, including disaster recovery; and
- publication of metrics to the ESDIS Metrics System that collects and organizes metrics from the DAACs and other data providers.

If prototypes developed as part of Project Cumulus are successful, an entire DAAC could be running in the cloud by 2020. According to ESDIS officials, the Global Hydrology Research Center DAAC data will be moved to the cloud and be operational by the end of FY 2020. Under this new architecture, the DAACs would still serve as gateways to EOSDIS Earth science data and continue to provide a wide range of support services for end users. While selected EOSDIS data and services are already operating in the cloud, ESDIS is still reviewing additional DAAC functions and data products to determine which collections might work best in the cloud.[20] This includes an evaluation of current DAAC data volume size and projected growth along with DAAC data distribution characteristics such as costs, efforts to implement, and risks to migrate. In addition to EOSDIS data products, ESDIS will also continue testing dataset-specific tools and applications in the cloud, which will be migrated to the cloud on a case-by-case basis. The overall objective is to package specific tools and applications to run in the commercial cloud, especially those that can be used across multiple DAACs and with multiple datasets. As a result of Project Cumulus, Earthdata Cloud will be the operational platform in which EOSDIS data is eventually stored.

Earthdata Cloud

The goal of Earthdata Cloud, which is the planned operating environment within AWS, is for the ESDIS to develop, test, and deploy commercial cloud environments to realize storage, processing, and operations efficiencies; improve cross-DAAC collaboration; and provide new data access and services. This will enable end users to work across multiple large data sets managed by different DAACs without the need to transmit data over networks, which will streamline distribution of data. Beginning in 2021, the NISAR and SWOT missions will be the first large Earth science missions to ingest, archive, and distribute data directly via Earthdata Cloud.

[20] Earthdata Search and the Common Metadata Repository evolved to the cloud in September 2016 and April 2017, respectively.

Earth Science and Cloud Budget

ESDS is the NASA headquarters program office that funds the ESDIS project. An ESDIS resource team is responsible for budget planning and execution of the entire ESDIS budget, including allocation of funds to each DAAC and SIPS. In FY 2019, the ESDIS budget was $173 million, of which the DAACs accounted for roughly 46 percent, or $80 million.[21] Table 1 shows the total budget for the Earth Science Division, ESDIS, and the DAACs for FYs 2014 through 2019.

Table 1: Total Budget for Earth Science Components for FYs 2014 through 2019

Fiscal Year	Dollars in Millions[a]			DAAC Budget as a percentage of ESDIS
	Earth Science Division	ESDIS	DAACs	
2014	$1,825	$148	$69	46.62%
2015	1,784	155	72	46.45
2016	1,927	168	75	44.64
2017	1,908	178	82	46.07
2018	1,921	178	79	44.38
2019	1,931	173	79	45.66
Total	**$11,296**	**$1,000**	**$456**	**45.60%**

Source: NASA OIG analysis of Agency Information.

[a] As of April 2019. DAAC budget amounts exclude cost of civil servant labor.

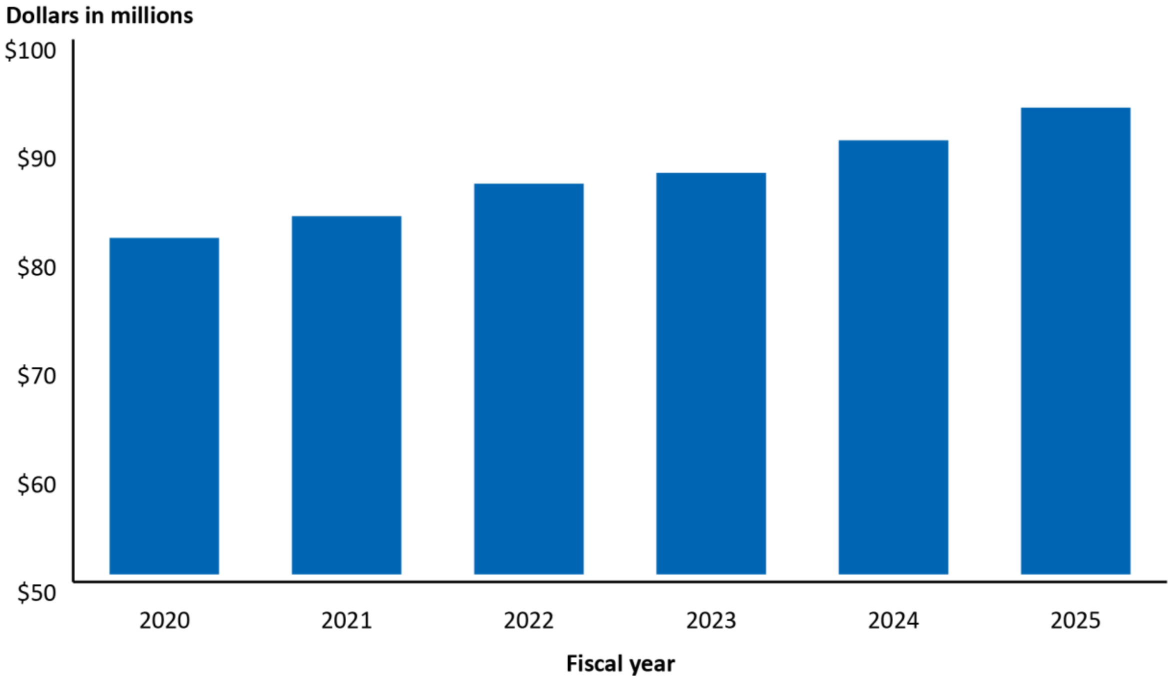
DAAC Budget Projections

ESDIS developed budget projections for FYs 2020 through 2025 and projected that over the next 6 years the DAAC budget will increase approximately 15 percent from $81 to $93 million between FYs 2020 and 2025.[22] Figure 4 shows the DAAC budget projections.

[21] The FY 2019 ESDIS total budget consists of $80 million in DAAC funding, an additional $20 million for the SIPSs, and other ongoing requirements.

[22] The large increase in projected budget is due to the NISAR and SWOT missions.

Figure 4: DAAC Budget Projections

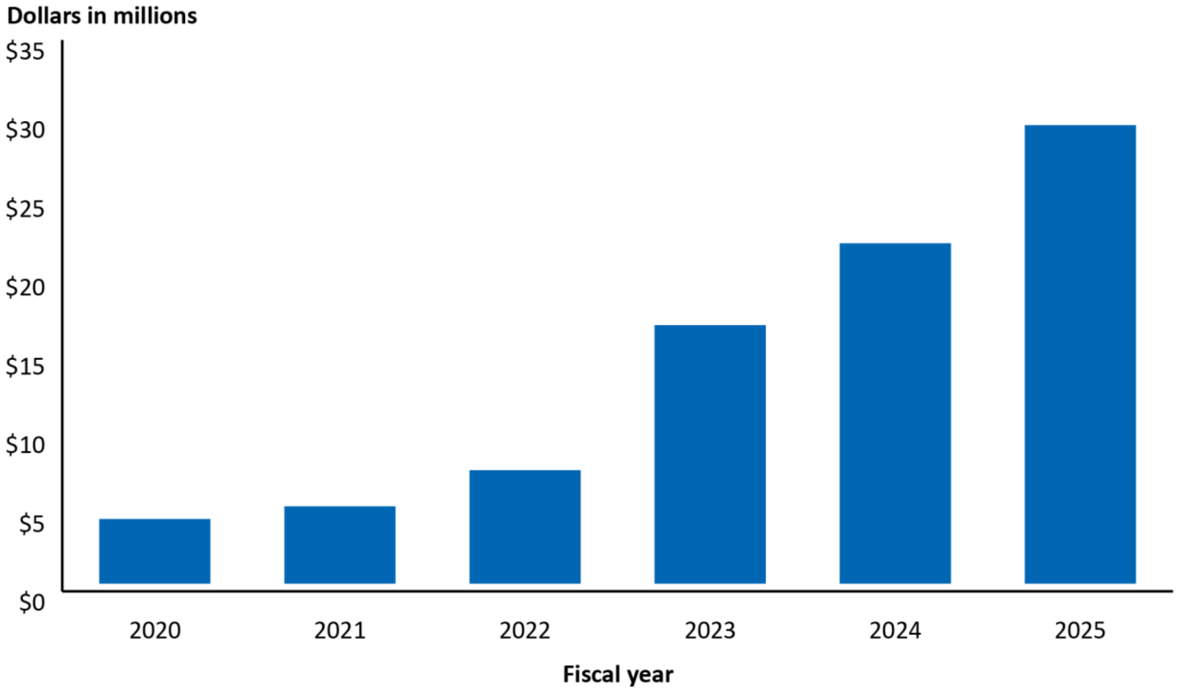


Source: NASA OIG analysis of ESDIS information.

ESDIS Cloud Budget Projections

The individual missions and projects within ESDIS submit for review and approval anticipated cloud costs for the budget execution year plus an additional 5 years. The requirements are incorporated into ESDIS's annual budget request, which is submitted to the Science Mission Directorate. Over the last 3 years, ESDIS has spent $3.2 million on cloud activities and expects its cloud budget to steadily increase for the foreseeable future (see Figure 5). The cloud costs noted in Figure 5 are in addition to the costs required to maintain the DAACs represented in Table 1.

Figure 5: ESDIS Cloud Budget Projections



Source: NASA OIG analysis of ESDIS information.

Earth Science Data Stored in the Cloud Expected to Exponentially Increase, Leading to Increased Costs and Management Challenges

Agency officials expect the volume of Earth observation data stored in the cloud to exponentially increase due to several future high-data-volume missions. To accommodate this huge increase in data, ESDIS officials need to ensure that an increase in data volume does not result in unsustainable costs. Such dramatic increases in the overall size of the DAAC archive through 2025 presents multiple challenges to NASA, including the possibility of substantial cost increases to the Agency for data egress and the lack of operational experience with a cloud-based architecture. In addition, ESDIS has yet to determine which data sets will transition to the cloud nor has it developed cost models with the benefit of operational experience and metrics for usage and egress. As a result, cost projections may be lower than what is necessary to cover expenses and cloud adoption may become expensive and more difficult to manage. There is a risk scientific data may become less available to end users if NASA imposes limitations on the amount of data egress for cost control reasons.

Adoption of Cloud May Be Costly as Volume of Data is Expected to Significantly Increase

As a result of a TCAT review completed in 2014, an Evolution, Enhancement, and Efficiency (E&E) review panel recommended ESDIS develop, implement, and report on the advantages, risks, and costs of using commercial cloud environments. ESDIS is in the early stages of cloud migration and the complexity of Earth observation data makes it impossible to simply move data en masse from the DAACs to the cloud. From its current size of approximately 32 petabytes, the volume of data in the EOSDIS archive is expected to increase to approximately 247 petabytes by 2025 as several new missions—most significantly NISAR and SWOT—come online and begin producing data. The anticipated growth in the overall data volume poses a new challenge for archive and distribution of datasets that are currently stored and disseminated through physical servers located at the DAACs. According to ESDIS, procuring the hardware to store and archive these high volumes of data at the DAACs would be cost prohibitive and therefore adopting cloud technologies is the best alternative. To prepare for this tremendous growth and efficiently provide access to these datasets, in July 2018, ESDIS began deploying Earthdata Cloud. ESDIS initially projected an entire DAAC could be running in the Earthdata Cloud by 2019 or 2020.

Currently, EOSDIS houses 11,000 data sets with end users accessing data directly from the DAACs without NASA incurring egress charges. However, beginning in 2021, the NISAR and SWOT missions will be the first large Earth Science mission datasets that ESDIS will manage utilizing Earthdata Cloud via AWS commercial cloud services. End user demand for NISAR is expected to be high due to ultra-sharp imagery that will facilitate cutting-edge research into some of the planet's most complex processes, including ecosystem disturbances, ice-sheet dynamics, earthquakes, tsunamis, volcanoes, and landslides. Likewise, the SWOT mission will produce the first global survey of Earth's surface water, observe the fine details of the ocean's surface topography, and measure how water bodies change over time. In total, the NISAR and SWOT missions will contribute an additional 215 petabytes to the data EOSDIS stores by 2025. Specifically, as of March 2019, NISAR is expected to generate approximately 86 terabytes of data each day, while SWOT will generate 20 terabytes. Furthermore, from 2020 through 2022, eight more Earth science missions, each with a combined estimated daily data volume of 9 terabytes, will potentially store data on the cloud (see Figure 6). This anticipated growth in both the EOSDIS data ingest rate as well as the overall archive volume pose new challenges for distributing and analyzing data currently stored and disseminated through physical, on-premise servers at the DAACs. These upcoming missions are driving the need for ESDIS to manage this data in a scalable, cost-effective cloud environment.

Figure 6: Current and Future Earth Science Missions

Current Earth Science Missions Storing Data with the DAACs

- Aura
- Cloud Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO)
- Cyclone Global Navigation Satellite System (CYGNSS)
- ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS)
- Global Ecosystem Dynamics Investigation Lidar (GEDI)
- Gravity Recovery and Climate Experiment Follow-on (GRACE-FO)
- Ice, Cloud, and land Elevations Satellite-2 (ICESat-2)
- Lightning Imaging Sensor (LIS)
- Orbiting Carbon Observatory-2 (OCO-2)
- Orbiting Carbon Observatory-3 (OCO-3)
- Ocean Surface Topography Mission (OSTM)/Jason-2
- Stratospheric Aerosol and Gas Experiment III (SAGE III)
- Soil Moisture Active Passive (SMAP)
- Solar Radiation and Climate Experiment (SORCE)
- Suomi National Polar-orbiting Partnership (S-NPP)
- Terra

Future Missions Storing Data on the Cloud

- Climate Absolute Radiance and Refractivity Observatory (CLARREO) Pathfinder
- GeoCARB
- Joint Polar Satellite System-2 (JPSS-2)
- Multi-Angle Imager for Aerosols (MAIA)
- NASA-ISRO Synthetic Aperture Radar (NISAR)
- Pre-Aerosol, Clouds, and ocean Ecosystem (PACE)
- PREFIRE
- Sentinel-6 A
- Tropospheric Emissions: Monitoring of Pollution (TEMPO)
- Time-Resolved Observations of Precipitation structure and storm intensity with a Constellation of Smallsats (TROPICS)

Source: NASA OIG representation of ESDIS provided Information.

Currently, NASA has a 5-year (May 2018 through May 2023), $65 million task order with AWS for cloud services for the entire Agency. As the NASA entity with one of the largest Earth Science datasets in the world, some of which will move to the cloud, ESDIS is projecting it will require $36 million, or 55 percent, of NASA's total AWS task order amount through May 2023.[23] As of March 2019, ESDIS has spent $3.2 million on cloud services and expects cloud costs will increase to $21.6 and $29.1 million in FYs 2024 and 2025, respectively. In addition to funding and supporting cloud access and egress for both current and future high-volume-data missions, ESDIS plans to maintain the current footprint of 12 fully functional DAAC sites. For FYs 2014 through 2019, the cost to maintain the DAACs ranged from $69 to $80 million, and costs are expected to increase to $90 million and $93 million in FYs 2024 and 2025, respectively. Therefore, to maintain both the DAACs and the cloud, ESDIS may require approximately $122 million in FY 2025.

[23] According to an OCIO official, if the task order ceiling reached prior to the end of the performance period, NASA will award another task order.

Cloud Adoption May be Difficult to Manage Due to Several Uncertainties

Increase in Potential Egress Costs

Given the high number of end users expected to request NASA data and the significant increase in data expected to be available between now and FY 2025, egress charges are also expected to increase. Currently, when end users access and egress data through a DAAC there is no additional charge to NASA other than maintaining current infrastructure costs. However, the cost structure will change significantly as NASA migrates large datasets to the cloud because allowing end users to download data from a private cloud service supplier such as AWS will result in egress charges that NASA, not the end user, will pay. Egress charges vary by provider and are almost always more expensive than the price to move data into the cloud, with public cloud providers charging a fee every time end users pull data from cloud storage to on-premise storage. Complicating the matter, the market rates for storage and egress can fluctuate on a daily basis, making it difficult for the Agency to project costs.[24] For instance, if a user downloads data to research and analyze on their local computer this will result in charges at the varying market rate to NASA in addition to the cost of maintaining current on-premise infrastructure. ESDIS officials said they plan to educate end users on accessing data stored in the cloud, including providing tools to enable them to process the data in the cloud to avoid egress charges.

ESDIS will be responsible for paying both cloud costs, including egress charges, and the costs to operate its 12 DAACS. To mitigate the challenges associated with potential high egress costs when end-users access data, ESDIS plans to monitor such access and "throttle" back access to the data—that is, providing traffic shaping as a means to control the volume of egress. This practice can ultimately result in turning off the data pipeline after a predetermined cost ceiling has been reached, resulting in the service being unavailable to end users until the following month when the billing cycle begins again. Throttling is similar to the concept of a wireless carrier in that NASA pays for a certain amount of data access prior to meeting an egress threshold at which point NASA has management capabilities to monitor and control the download of data. While ESDIS is taking steps to address these uncertainties, there is an increased risk that scientific data may become unavailable to end users and cloud adoption may become financially unsustainable. Finally, ESDIS officials identified the cost of transitioning its data from AWS to another cloud provider or removing the data from the cloud altogether as a top risk for Earthdata Cloud.

Cost Models Prepared with Non-Operational Data and Data Egress Uncertainties

Earthdata Cloud has only been operational for a short period of time and NASA's cloud cost forecast models were developed without the benefit of operational experience and metrics. As a result, ESDIS officials raised the possibility that their initial cost modeling may be incorrect. In 2016, ESDIS was asked to develop early technical concepts and cost estimates for upcoming missions. Working with the Physical Oceanography DAAC, ESDIS developed scenarios for how they might archive and distribute SWOT data. According to an ESDIS representative, the outcome of the study was a simple cost estimate for SWOT data and approval to go forward with further cloud efforts. However, the official also stated

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[24] NASA pays the market rate at the time of consumption for any cloud service utilized, including egress.

that the cloud solution ESDIS is currently pursuing is more complex and thus more costly than the plan originally considered in 2016. Furthermore, in an attempt to mitigate this risk, ESDIS has funded three entities to model operational egress and storage needs based on available data and provide recommendations.[25] According to ESDIS officials, these studies should provide multiple perspectives on both how actual data distribution is predicted to proceed and how ESDIS might deal with poor prediction. To put potential egress charges into perspective, the Alaska Satellite Facility DAAC noted that during the expected spike of data from NISAR in FYs 2023 and 2024, egress costs alone could be approximately $6 million per year for that single mission. Furthermore, with the ESDS archive expected to exponentially increase, estimated egress costs for the archive could be as high as $9 million per year. ESDIS officials said they plan to develop a process for adjusting data storage and egress models based on actual operations as they approach SWOT and NISAR milestones.

Further complicating matters, AWS is currently the only cloud vendor authorized by the OCIO to provide cloud services. According to ESDIS, this introduces the risk of a single point of failure because all Earth science data will be stored with one vendor. Furthermore, ESDIS indicated that if they were to utilize additional vendors, the costs associated with egressing and transferring data stored with AWS to other providers may be exorbitant. The OCIO is in the process of adding additional commercial cloud vendors in NASA's portfolio and ESDS is investigating the feasibility of using them to manage EOSDIS data. New vendors are expected to be added in the second quarter of FY 2020. In addition, ESDIS is investigating a long-term archive backup solution that would maintain a copy of the data, allowing NASA to avoid potential egress charges or lack of availability in the event a different vendor is selected at a later date.

ESDIS Has Yet to Determine Which Data Sets Will Migrate to the Cloud

In July 2019, ESDIS developed the Earthdata Cloud Prioritization Plan to prioritize DAAC datasets, as well as future mission data, for migration to the cloud.[26] The plan is pursuing a multi-perspective approach—split into DAAC community involvement and decision making phases—to identify priority datasets for an incremental migration into the commercial cloud. ESDIS has identified primary migration goals, but all of the specific datasets to migrate to the cloud have yet to be determined.[27] As of October 2019, some datasets for 6 of the 12 DAACs have been selected for migration to the cloud beginning the first quarter of FY 2020. For example, the Global Hydrology Research Center DAAC is on track for using Cumulus for parallel operations (publishing datasets both on-premise and within the cloud). All of the datasets for this DAAC, totaling approximately 30 terabytes, will be migrated to the cloud and are expected to be operational by the end of FY 2020. During the first quarter of 2020, ESDIS will continue to identify and rank datasets to determine the order of data migration to the cloud. The goal is to balance usability with cost effectiveness when making decisions regarding the type of data to be migrated to the cloud.

[25] Alaska Satellite Facility DAAC, AWS ProServe, and Forrester.

[26] NASA ESDIS, *Earthdata Cloud Dataset Prioritization Plan* (July 7, 2019).

[27] ESDIS has identified largest volume of data, most popular data, most complimentary data for the NISAR and SWOT missions, progressing science to the highest degree, and Earthdata Cloud resource capacity building as their primary cloud migration goals.

ESDIS and the OCIO Not Consistently Involved Early in Decision Making that Impacts Data Management

NASA space flight and research program and project management requirements do not detail specific direction for organizations to coordinate with ESDIS and the OCIO when creating data management plans. This omission creates gaps between overall NASA procedural requirements and ESDIS and OCIO data management requirements. Failure to involve ESDIS and the OCIO early in the decision making process on the types and amount of data to be collected, processed, and stored by a mission hinders their ability to ensure that metadata standards and data formats are appropriately considered and that infrastructure and security requirements are addressed.[28] Regardless of the size of the mission or amount of data collected through observations, the raw data for all Earth science missions must be captured, processed, archived, and distributed to the scientific community in a format that is identifiable, accessible, interoperable, and reusable and both ESDIS and the OCIO play important roles in this process. Specifically, ESDIS is responsible for ensuring data is ingested in usable formats and that data and metadata standards are adhered to, while the OCIO is responsible for administering NASA's cloud services and ensuring the data can be accessed by end users in a secure environment to protect its confidentiality, integrity, and availability.

ESDS guidance states that each organization funded by NASA to produce Earth science data is required to prepare a data management plan at the time it is funded and to maintain that plan as a living document by reviewing it periodically and ensuring it is up-to-date. NASA has more encompassing policies that also direct the development of data management plans. Specifically, NASA Procedural Requirement (NPR) 7120.5E, *NASA Space Flight Program and Project Management Requirements*, instructs a program to describe how it will manage the scientific data generated and captured by the operational mission(s).[29] Furthermore, NPR 7120.8A, *NASA Research and Technology Program and Project Management Requirements*, states that data management and distribution is optional but recommends that plans that are developed should detail how data will be collected, stored, and accessed.[30] However, NASA program and project guidance does not direct programs to consult ESDIS or the OCIO when creating their data management plans, potentially leaving them without knowledge or input into the amounts, types, and structure of data to be ingested, processed, and archived.

When missions fail to consult ESDIS in developing a data management plan there is an increased risk of schedule delays, poor data quality, or expensive redesign by the projects and/or the DAACs. For example, data for the African Synthetic Aperture Radar (AfriSAR) mission was not assigned to a DAAC

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[28] Metadata is a set of data that describes and gives information about other data.

[29] NPR 7120.5E, *NASA Space Flight Program and Project Management Requirements* (2012).

[30] NPR 7120.8A, *NASA Research and Technology Program and Project Management Requirements* (2018).

until well after the mission had flown.[31] As a result, according to ESDIS officials, datasets have been submitted in inconsistent, nonstandard formats making it difficult to create archive-stable products that are compatible with the assigned DAAC. Furthermore, as many of the investigators associated with the mission had moved on to other projects by the time the mission started submitting data, it continues to be difficult for the DAAC to track down critical details on the datasets or complete the associated end user guides used to access the data. Officials noted that AfriSAR data management planning may have lacked early visibility due to the mission's relatively small size. This type of delay affects early engagement with data stewards, potentially creating the need for rework if the data are found to have significant usability or interoperability issues. In addition, transitioning data storage to the cloud increases the importance of early formatting and data set discussions to ensure that only necessary data is stored to optimize cloud usefulness and minimize costs.

Conversely, in instances where early ESDIS involvement did occur, the DAACs were able to establish operational data capabilities that improved data usability, broadened the scientific impact of the data, and were verified during pre-launch testing. For example, DAACs were assigned to the Soil Moisture Active Passive and Ice, Cloud and land Elevation Satellite-2 missions several years ahead of launch and before any datasets were designed and created.[32] This early engagement provided the DAACs with the opportunity to influence the data and metadata structures and to prepare the services and information needed to support this mission. As a result, ESDIS management noted a smooth transition once data was provided to and archived by the DAACs.

[31] The AfriSAR mission was an airborne campaign begun in 2016 that collected radar and field measurements of tropical forests in Gabon, West Africa. The mission was a NASA collaboration with the European Space Agency and the Gabonese Space Agency. NASA UAVSAR and LVIS instruments collected data that will be used to derive forest canopy height, structure, and topography. The AfriSAR data is a precursor to upcoming spaceborne missions that examine the role of forests in Earth's carbon cycle.

[32] The Soil Moisture Active Passive mission is an orbiting observatory launched in 2015 that measures the amount of water in the top 5 cm (2 inches) of soil on Earth's surface. Scientists will use the mission data to help improve our understanding of how water and carbon (in its various forms) circulate. The Ice, Cloud and land Elevation Satellite-2mission, part of NASA's Earth Observing System, is a satellite mission launched in 2018 to measure ice sheet elevation and sea ice thickness as well as land topography, vegetation characteristics, and clouds.

ESDS System Security Plans Need Improvement to Help Ensure Integrity of Earth Science Data

While DAAC security plans generally followed NASA and NIST requirements, ESDIS deviated from the NIST-recommended moderate impact level for data integrity. When conducting its security assessment, ESDIS assessed the impact level based on the ability to reprocess data in the event it were improperly modified or destroyed and not on the overall value of the system and underlying data. In addition, ESDIS excluded critical information types when conducting system impact determinations. This occurred because responsible parties misinterpreted NASA and NIST categorization guidance due to a lack of close OCIO involvement. To help ensure data processed by a DAAC is adequately protected, NIST provides guidance for system categorization, including a library of information types with recommended impact levels to determine whether a system should operate at the low, moderate, or high impact level.[33] Failure to appropriately categorize systems and data can result in inadequate controls for protecting the confidentiality, integrity, and availability of the system and or its data.

Data Categorization Requirements

System and data categorization is an important step in managing risk to an information system. This process is designed to provide a foundation for determining the security controls that should be applied to an information system commensurate to its criticality in an effort to ensure appropriate confidentiality, integrity, and availability. When preparing to apply security to a system and the data processed within that system, information system owners first need to determine the criticality of the system and its data. NIST guidance details potential information types that may be processed by a federal information system, including scientific data, budget data, human resources data, systems management data, and many others. Systems processing classified information are covered in other federal guidance. NASA has adopted the NIST guidance as its standard for categorizing Agency information systems.

NIST Federal Information Processing Standards Publication 199, *Standards for Security Categorization of Federal Information and Information Systems*, and Special Publication (SP) 800-60, Volumes 1 and 2, *Guide for Mapping Types of Information and Information Systems to Security Categories*, detail system categorization procedures.[34] This guidance provides procedures for determining if a system should be

[33] NIST SP 800-60, Volumes 1 and 2, *Guide for Mapping Types of Information and Information Systems to Security Categories* (August 2008). Information type is a specific category of information (e.g., privacy, medical, proprietary, financial, investigative, contractor sensitive, and security management) defined by an organization or in some instances by a specific law, Executive Order, directive, policy, or regulation. Categorizing a system based on the information it processes is important because it determines what controls should be applied to manage risk. Information systems are categorized as "high," "medium," or "low" based on the information they process.

[34] NIST Federal Information Processing Standards Publication 199, *Standards for Security Categorization of Federal Information and Information Systems* (May 25, 2018), and NIST SP 800-60, Volumes 1 and 2.

categorized as either low, moderate, or high impact. These categorizations are based on the potential impact on an organization should certain events occur that would jeopardize the information and systems needed by the organization to accomplish its assigned mission, protect its assets, fulfill its legal responsibilities, maintain its day-to-day functions, and protect individuals (see Figure 7 for system categorization definitions).

Figure 7: System Security Categorization Level Definitions

LOW
The loss of confidentiality, integrity, or availability could be expected to have a *limited adverse* effect on organizational operations, organizational assets, or individuals

MODERATE
The loss of confidentiality, integrity, or availability could be expected to have a *serious adverse* effect on organizational operations, organizational assets, or individuals

HIGH
The loss of confidentiality, integrity, or availability could be expected to have a *severe adverse* effect on organizational operations, organizational assets, or individuals

Source: NIST Federal Information Processing Standards Publication 199.

As the system function becomes more critical or the data processed within more influential, the impact level of the security category increases. NASA guidance allows for deviations from these impact levels if the NASA information system owner can provide adequate justification.

Inappropriate Justification When Deviating from NASA and NIST Guidance

In our review of ESDIS security plans, we found that all four Goddard-located DAACs and Earthdata Cloud were categorized as “low” impact using a mix of information types, including environmental monitoring and forecasting data. The security plans and our discussions with both ESDIS management and subject matter experts in system and data security identified critical but incorrect assumptions were used when making the system categorization determinations—assumptions that deviated from NIST guidance. NASA procedural guidance allows for deviations from NIST impact levels if the NASA information system owner can provide adequate justification for the deviation based on the value of the system and data processed within the system. NIST states the integrity impact level should be based on the specific mission and the data supporting that mission, not on the time required to detect the modification or destruction of information. However, the justifications used to deviate from a moderate to low categorization for the four Goddard DAACs and Earthdata Cloud were based upon compensatory or mitigating controls or factors rather than the value of the system and the data processed within the system.

According to Agency officials, ESDIS did not follow NIST guidance because the information systems were not operational systems but rather systems that only store, process, and distribute scientific data. As such, they felt the deviation was justified. The categorization records also indicate that deviations were made based on ESDIS’s capability to reprocess data internally in the event data integrity was compromised. NIST warns against using this justification because it is based not on the data and system, but rather on mitigating factors to detect and repair either intentional or erroneous modification or destruction after it has occurred.[35] Furthermore, ESDIS officials stated that to meet OMB’s open-sharing

[35] NIST SP 800-60 Volumes 1 and 2.

requirements for data, it is easier to operate at a low impact level, which requires fewer security controls that cost less to develop and maintain, than at the moderate impact level, which requires an increased number and complexity of security controls.[36] ESDIS officials also stated that system security guidance is interpreted differently across NASA locations. However, in our judgment, ESDIS's deviations in this area do not conform to NASA or NIST guidance, which recommends a moderate impact level rating for the data integrity element for the type of data maintained at the DAACs.[37]

Failing to follow appropriate procedures when considering impact levels could not only lessen the perceived importance of a system but, perhaps more importantly, also impact the level of security controls put in place to protect the data. Low impact systems will exclude security controls entirely or exclude the control enhancements required for higher impact levels. For example, NIST identifies specific security controls related to information sharing as part of the Access Controls family that are not considered for data with a low impact rating while they are included for data that has been categorized as moderate or high impact.[38]

Important Information Types Excluded During System Impact Determinations

In reviewing the ESDIS DAAC security plans, we identified instances where certain information types contained in the system description were excluded. For example, we found the National Snow and Ice Data Center (NSIDC) DAAC security plan only addresses four information types—information management, information sharing, disaster recovery and restoration, and general data and statistics—while omitting other more appropriate information types, such as environmental monitoring and forecasting, in its impact level determination. This occurred because responsible parties misinterpreted NASA and NIST categorization guidance due to a lack of close coordination with the OCIO. As detailed in NIST guidance, the information management type involves the coordination of collecting, storing, disseminating, and destroying data as well as managing the policies, guidelines, and standards regarding information management. The NSIDC DAAC serves as NASA's primary archive for snow and ice data involving the observation and prediction of environmental conditions impacting ice sheet measurements. According to NIST guidance, the environmental monitoring and forecasting information type would have also been an appropriate information type to use when determining the DAAC's impact level.[39] Further, the NSIDC DAAC excluded scientific and technological research and innovation information, which also has a provisional impact recommendation as moderate. Additionally, had ESDIS consulted subject matter experts within the OCIO and properly considered the applicable information types when designating the impact rating for the system, it would have been rated as moderate rather than at a low impact level.
In addition, the Measurement of Pollution in the Troposphere (MOPITT) SIPS, which provides data to the Atmospheric Science Data Center DAAC for archive and distribution, failed to follow NASA and NIST guidance for selecting information types associated with the system but rather used generic MOPITT

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[36] M-13-13.

[37] Information Technology Security Handbook-2810.04-01A, *Risk Assessment, Vulnerability Scanning and Expedited Patching* (April 2019), provides NASA guidance for system categorization.

[38] NIST SP 800-53 Rev 4, *Security and Privacy Controls for Federal Information Systems and Organizations* (April 2013), provides guidance for selecting and applying security controls to federal information systems. These controls are organized into 18 control families. Controls within these families may involve aspects of policy, oversight, supervision, manual processes, actions by individuals, or automated mechanisms implemented by information systems/devices.

[39] According to NIST SP 800-60, any system processing and storing environmental monitoring/forecasting information types should be rated at the moderate impact level.

scientific data as the basis for its low impact determination. In this instance, the environmental monitoring and forecasting information type should have been applied along with other applicable information types. According to NIST SP 800-60, the environmental monitoring and forecasting information type includes information focused on monitoring ice sheets but also includes information on air quality in the troposphere, which is the primary mission of MOPITT.

SCIENCE MISSION DIRECTORATE DID NOT FULLY IMPLEMENT CAPABILITY STEERING COMMITTEE RECOMMENDATIONS TO IDENTIFY POTENTIAL COST SAVINGS

The Evolution, Enhancement, and Efficiency (E&E) panel selected by Mission Support Council (MSC) to perform an independent review of the DAACs failed to identify potential cost savings. In response to a TCAT assessment, in July 2014, the Capability Steering Committee (CSC) provided the MSC options regarding the future of the DAACs, including recommendations to identify potential costs savings to be reinvested in a future Earth science mission. MSC changed the CSC recommendation to exclude a 20 percent savings target and ESDS did not direct the panel to identify and quantify specific goals for cost savings. Additionally, 6 of 12 E&E panel members were not independent of ESDS, which may have affected the findings and recommendations of the review. Had the E&E panel been instructed to identify the recommended 20 percent cost savings target; those savings may have been available to help offset the increase in cloud storage costs.

TCAT and E&E Review Panel

As part of its evaluation of NASA's technical capabilities, in 2014, the TCAT team conducted an Earth Science Deep Dive Assessment that focused on several areas, including data management.[40] TCAT noted that Earth science data was distributed and generally well managed within the ESDS program. However, they also observed that data volume did not seem to correspond with the existing number of DAACs, workforce, and infrastructure and that this was an area for "potential additional investigation." As a result, in July 2014, CSC prepared a decision package outlining technical capability decisions arising from the TCAT assessment and providing three options and associated recommendations. The MSC reviewed the CSC decision package and documented its selection in a decision memorandum.[41]

The option selected by MSC proposed a challenge target of 20 percent savings, or approximately $20 million annually, to be reinvested in a new Earth science flight mission. To address the recommendation, the Earth Science Division was directed to sponsor an independent review to study potential efficiencies and enhanced capabilities from a variety of perspectives, including science discipline and optimization of common data operations tasks across the DAACs. Further, the review was to consider advancing current efforts to achieve efficiencies across the DAACs, including cloud computing, open source software, and dataset interoperability. Subsequently, the E&E Review Team was formed to conduct the review.

[40] This deep dive focused on basic research (research and analysis, applied sciences, technology development programs), data management, and computational modeling and simulation.

[41] The decision memorandum was signed by several high-level NASA officials, including the Associate Administrator; Chief Information Officer; Chief Financial Officer; Associate Administrator Mission Support Directorate; and Chief, Safety and Mission Assurance.

ESDS Did Not Direct E&E Panel to Identify Cost Savings and the Panel Lacked Independence

Although the MSC selected the CSC recommendation that required a 20 percent savings target, the MSC excluded that requirement when providing review direction to the Earth Science Division on establishing the E&E panel.[42] Instead, the MSC recommended that the Earth Science Division direct ESDS to establish the E&E panel and generally identify and quantify specific incentives or goals for cost savings to be achieved by ESDIS. However, for unknown reasons, the charter provided by ESDS to the E&E panel outlining the scope of their review did not require the E&E panel to identify savings to be achieved by ESDIS, thereby contradicting MSC's already altered recommendation.[43] As a result, the E&E panel did not develop any recommendations associated with identifying or quantifying goals for cost savings.

Additionally, in our view, 6 of the 12 members that made up the E&E panel were not independent because they were not external to the ESDS program. In March 2015, the MSC established a 12-member E&E review panel that originally was intended to be comprised of 10 to 12 individuals external to the ESDIS project and an expert ad hoc technical group comprised of representatives from the Earth Science Division, ESDIS project, DAACs, and broader EOSDIS community to assist the panel. While the 12-member E&E panel consisted of individuals from NASA, academia, and other federal agencies, 6 members, including the panel's chair, had current or former connections to ESDIS and the DAACs.

According to NASA guidance, independent assessments, including reviews, evaluations, audits, analysis oversight, and investigations, should be independent to the extent the involved personnel apply their expertise impartially and without any conflict of interest or inappropriate interference or influence, particularly from the organization being assessed.[44] Team members should be independent of the performing center or institution such that they have no stake or involvement in the design, build, or operation of the work being reviewed.

An alternative would have been for NASA to request that an external party conduct an independent assessment or that the panel be composed of individuals external to the ESDS program. According to the NASA Governance and Strategic Management Handbook, the Agency encourages and considers the results of external assessments, evaluations, and reports on their performance.[45] External evaluators include the NASA Advisory Council, the National Academies, NASA Office of Inspector General, the Office of Personnel Management, and the Government Accountability Office.[46] In fact, the National Academies performed a review of NASA's DAACs in 1999 and provided detailed recommendations on improving the operations of each DAAC with three underlying themes: (1) the scientific need for a coherent system of DAACs; (2) the importance of strategic planning in routine data center operations;

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[42] *Earth Science MSC Decision Memorandum*, MSC-2014-01-001d.

[43] Since the assessment was completed, key individuals associated with the process have left the Agency, limiting the ability to determine why certain decisions were made. However, the MSC serves as the Agency's senior decision-making body regarding the Agency missions support portfolio and ESDS would therefore be required to follow MSC's recommendation.

[44] NPR 7120.5E.

[45] NASA Policy Directive (NPD) 1000.0B, *NASA Governance and Strategic Management Handbook* (June 2014).

[46] NPD 1000.0B. The NASA Advisory Council draws on the expertise of its members and other sources to provide advice and make recommendations to the NASA Administrator on Agency programs, policies, plans, financial controls, and other matters. The National Academies of Sciences, Engineering, and Medicine are private, nonprofit organizations that advise the government on questions of science, technology, and health policy.

and (3) the need for flexibility, vision, and leadership as EOSDIS evolves.[47] In our judgment, selecting half of the E&E panel members from within NASA, ESDS, and the DAACs did not allow for an objective, independent review of the DAACs. Independent reviews are important to the Agency's oversight of programs and projects and enhance management accountability. They also provide a program and NASA senior management with objective assessments of a program's progress, issues, and risks.

As a result of the E&E panel review, ESDIS expanded efforts for implementing cloud prototypes to explore the advantage, risks, and costs of using commercial cloud environments. In 2016, ESDIS began migrating DAAC data to the cloud. At the same time, it has maintained the current DAAC footprint which in FY 2019 cost $80 million. From FYs 2020 to 2025, cloud costs are expected to increase by $25 million on top of the costs to maintain the DAACs.

[47] NRC, *Review of NASA's Distributed Active Archive Centers* (1999).

CONCLUSION

Whether or not cloud computing reduces overall costs for an organization depends on a careful analysis of all costs of operation, needed infrastructure, security, and costs to migrate data to and from the cloud. Mitigation of uncertainties and risks associated with future data volume and egress costs, collaboration between affected stakeholders, and correctly categorizing information systems to ensure data integrity are essential for archive and dissemination of valuable Earth science data to end users. Additionally, the long-term sustainability of maintaining the current DAAC footprint in conjunction with moving more data to cloud storage is dependent upon the Agency's ability to manage risks and keep costs at a reasonable level. As stewards of NASA's Earth science data, it is imperative the Agency closely monitors ESDIS's risk management practices to ensure the data is being managed effectively and that costs are controlled.

RECOMMENDATIONS, MANAGEMENT'S RESPONSE, AND OUR EVALUATION

In order to mitigate the risks associated with the migration to the cloud, improve data management planning, and enhance system security categorizations, we made the following recommendations to NASA's Associate Administrator for Science Mission Directorate:

1. In conjunction with ESDIS, once NISAR and SWOT are operational and providing sufficient data, complete an independent analysis to determine the long-term financial sustainability of supporting the cloud migration and operation while also maintaining the current DAAC footprint.
2. In conjunction with the Earth Science Division, provide comments during the NPR review cycle to the Office of the Chief Engineer for incorporating in both NPR 7120.5E and NPR 7120.8A, language specifying coordination with ESDIS and the OCIO early in a mission's life cycle during data management plan development.
3. In coordination with the OCIO, and during the next security plan review cycle, ensure all applicable information types are considered during system categorization, that appropriate premises are used when determining impact levels, and that the appropriate categorization procedures are standardized across ESDIS systems.

We provided a draft of this report to NASA management who concurred with the recommendations and described planned actions to address them. We consider the proposed actions responsive to our recommendations and will close the recommendations upon completion and verification of the proposed actions.

Management's comments are reproduced in Appendix C. Technical comments provided by management have also been incorporated, as appropriate.

Major contributors to this report include Ridge Bowman, Space Operations Director; Scott Riggenbach, Project Manager; Christopher Reeves; Sarah Beckwith; Barbara Moody; and Sarah McGrath.

If you have questions about this report or wish to comment on the quality or usefulness of this report, contact Laurence Hawkins, Audit Operations and Quality Assurance Director, at 202-358-1543 or laurence.b.hawkins@nasa.gov.

Paul K. Martin
Inspector General

APPENDIX A: SCOPE AND METHODOLOGY

We performed this audit from December 2018 through January 2020 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives. Our overall audit objective was to assess NASA's management of the DAACs and EOSDIS's cloud transition efforts. The scope of this audit encompassed the DAAC organizational and governance structure, management of risks to data and DAACs, the management of the cloud transition, and Agency actions in response to the TCAT assessment.

To gain an understanding of how the DAACs are managed and EOSDIS's cloud transition efforts, we performed work at NASA Headquarters; Goddard Space Flight Center; Oak Ridge National Laboratory Center; and the National Snow and Ice Data Center. We interviewed representatives from the OCIO and the Earth Science Division, Goddard Space Flight Center's ESDIS Manager and Deputy Manager, Budget, Procurement, and Cloud initiative. In addition, we spoke with the following DAAC managers: Goddard Crustal Dynamics Information System; Goddard Earth Sciences Data and Information Services Center; MODIS Level 1 and Atmosphere Archive and Distribution System; Ocean Biology, Socioeconomic Data and Applications Center, Land Processes, Oak Ridge National Laboratory, and the National Snow and Ice Data Center. We also interviewed managers from some related SIPS. We interviewed E&E panel members and reached out to the previous TCAT members who reviewed the DAACs in 2012. Those members are now located at the Ames Research Center, Jet Propulsion Laboratory, and NASA Headquarters.

We reviewed federal and NASA, policies, procedures, and supporting documentation; external reviews; and other documents related to cybersecurity, cloud implementation, TCAT, DAAC operations, Open Access, and data management. The documents we analyzed and reviewed included, but were not limited to, the following:

- Office of Science and Technology Policy, *Increasing Access to the Results of Federal Funded Scientific Research* (February 22, 2013)
- OMB Circular A-130 Revised, *Managing Information as a Strategic Resource* (no date)
- OMB, *Federal Source Code Policy: Achieving Efficiency, Transparency, Innovation, Through Reusable and Open Source Software* (August 8, 2016)
- General Services Administration, *Using Federal Information Technology Act Reform Act (FITARA) as a Lever for Change* (April 2016)
- *NASA Plan for Increasing Access to the Results of Scientific Research* (December 2014)
- NASA Office of the Chief Information Officer, *NASA FITARA Implementation Plan* (November 2015)
- *NASA's Plan for Increasing Access to the Results of Scientific Research* (November 21, 2014)
- *Earthdata Cloud Risk Assessment Report* (May 4, 2018)
- *Earthdata Cloud System Data Security Plan* (February 26, 2016)
- *ESDIS Risk Management Plan* (February 2019)

- *ESDS Risk Assessment Report* (February 2, 2017)
- *ESDS DAAC 2015 Efficiency and Effectiveness Panel Report* (November 2015)
- NPD 1000.3E, *NASA Organization w/Change 51* (April 15, 2015)
- NPR 7120.5E, *Space Flight Program and Project Management w/Changes 1-16* (August 14, 2012)
- NPR 1080.018, *Requirements for the Conduct of NASA Research & Technology (R&T)* (February 21, 2017)
- NIST SP 800-145, *The NIST Definition of Cloud Computing* (September 2011)
- *ORNL Computer Security Incident Reporting* (March 12, 2019)
- National Academy of Sciences, *Report Accessibility and Usefulness of NASA's Earth and Space Science Mission Data* (2002)
- *Forrester Consolidated Business Case Phase 2 V Final* (June 2018)
- *ESDS DAAC E&E Review Team Charter* (April 6, 2015)
- *DAAC E&E Review Team Findings and Recommendations* (August 17, 2015)
- *Mission Support Council Decision Package from TCAT* (July 2014)

Use of Computer-Processed Data

We used computer-processed data to perform this audit, and that data was used to materially support findings, conclusions, and recommendations. In order to assess the quality and reliability of the data, we compared the information with other available supporting documents, corroborating it with ESDS program documents and the input of various ESDS officials. From these efforts, we believe the information we obtained is sufficiently reliable for this report.

Review of Internal Controls

We reviewed and evaluated internal controls related to the formation of the E&E review team; finding that not all team members selected were independent from ESDS; potentially resulting in a less than impartial E&E assessment report.

Prior Coverage

During the last 5 years, the NASA Office of Inspector General (OIG) and the Government Accountability Office (GAO) have issued eight reports and one testimony of significant relevance to the subject of this report. Unrestricted reports can be accessed at https://oig.nasa.gov/audits/auditReports.html and http://www.gao.gov, respectively.

NASA Office of Inspector General

NASA's Efforts to "Rightsize" Its Workforce, and Other Supporting Assets (IG-17-015, March 21, 2017)

Security of NASA's Cloud Computing Service's (IG-17-010, February 7, 2017)

Review of NASA's Information Security Program (IG-16-016, April 14, 2016)

Federal Information Security Management Act: Fiscal Year 2015 Evaluation (IG-16-002, October 19, 2015)

Government Accountability Office

Data Center Optimization: Additional Actions Needed to Meet OMB Goals (GAO-19-241, April 11, 2019)

Cloud Computing: Agencies Have Increased Usage and Realized Benefits, but Cost and Savings Data Need to Be Better Tracked (GAO-19-58, April 4, 2019)

Information Technology: Implementation of Recommendations is Needed to Strengthen Acquisitions, Operations, and Cybersecurity (GAO-19-275T, December 12, 2018)

Data Center Optimization: Agencies Need to Complete Plans to Address Inconsistencies in Reported Savings (GAO-17-388, May 18, 2017)

Cloud Computing: Additional Opportunities and Savings Need to Be Pursued (GAO-14-753, September 25, 2014)

Appendix B: DAAC Locations and Scientific Disciplines

Table 2: DAAC Locations and Scientific Expertise, as of March 2019

DAAC	Location	Scientific Activity	Budget (dollars in millions)	Staffing
Atmospheric Sciences Data Center (ASDC)	NASA Langley Research Center	• Sensor-specific search tools as well as more general tools and services, such as atmosphere product subsetting • Provides unique expertise on Earth Radiation Budget, solar radiation, atmosphere composition, tropospheric chemistry, and aerosols • Connectivity to Langley Research Center science teams	$10.00	46.8 Work Year Equivalent (WYE), 5.0 Full Time Equivalent (FTE)
Alaska Satellite Facility (ASF)	Geophysical Institute at the University of Alaska, Fairbanks	• Provides specialized support in Synthetic Aperture Radar processing and enhanced data products for science researchers • Provides science support for polar processes and land vegetation measurements associated with Synthetic Aperture Radar instruments	8.70	38.6 WYE
Crustal Dynamics Data Information System (CDDIS)	NASA Goddard Space Flight Center	• Provides specialized data services in space geodesy and solid Earth dynamics • Connectivity to NASA Space Geodesy Network of observing systems	1.20	6.0 WYE, 1.0 FTE
Goddard Earth Sciences Data and Information Services Center (GES DISC)	NASA Goddard Space Flight Center	• Provides expertise is atmosphere composition and dynamics, global precipitation, and global modeling • Provides expertise in interactive web-based visualization and analysis tools; tools for subsetting, format conversion, data quality screening, and web-based OpenSearch services	8.90	35.9 WYE 7 FTE
Global Hydrology Research Center (GHRC)	NASA Marshall Space Flight Center and the University of Alabama's Information Technology and Systems Center	• Manages field campaign data from the Global Precipitation Measurement Ground Validation Program and the Hurricane Science Research Program, which includes the Hurricane and Severe Storm Sentinel Venture mission, as well as satellite passive microwave data for analysis of our climate and the water and energy cycle	1.50	6.7 WYE, 0.8 FTE

DAAC	Location	Scientific Activity	Budget (dollars in millions)	Staffing
Land Processes (LP)	U.S. Geological Survey Earth Resources Observation and Science Center in Sioux Falls, South Dakota	• Provides expertise, tools, and services for discovery and analysis of NASA's land cover and land use data • Provides expertise in Geographical Information Systems • Connectivity to LANDSAT data • Co-located with U.S. Geological Survey Remote sensing facilities	$7.50	33.8 WYE
MODIS/VIIRS Level 1 and Atmosphere Data System (LAADS)	NASA Goddard Space Flight Center	• Provides access to a complement of MODIS and VIIRS Level-1 and higher-level products • Provides web services based on both open standards and in-house as additional means to acquire desired data products • Offers access to relevant open source tools to handle the LAADS product collections	7.22	29.6 WYE, 3.5 FTE
National Snow and Ice Data Center (NSIDC)	Cooperative Institute for Research in Environmental Sciences, a joint Institute of University of Colorado Boulder and the National Oceanic and Atmospheric Administration	• Provides unique expertise in snow and ice datasets including the arctic ice minimum/maximum extents, experts in Arctic Sea Ice and Greenland Ice Sheets	7.50	39.5 WYE
Ocean Biology (OB)	NASA Goddard Space Flight Center	• Responsible for ocean color standard products and sensor calibration/characterization • Provides end user enable processing software using SeaDAS, product validation by end users through SeaBASS • Archives and distributes from missions and instruments providing stewardship for all products at the OB DAAC. Provides expert support to end users on ocean color data and dynamics.	4.60	20 WYE
Oak Ridge National Lab (ORNL)	Department of Energy's Oak Ridge National Laboratory	• Provides specialized data tools and services for terrestrial ecologists including the Spatial Data Access Tool, WebGIS, and MODIS Land Product Subsets. These tools enable ecologists to focus on data parameters from instruments like MODIS without having to break down large volume datasets. • Co-located with the Dept. of Energy Atmosphere Radiation Measurement Climate Research Facility	4.26	14 WYE

DAAC	Location	Scientific Activity	Budget (dollars in millions)	Staffing
Physical Oceanography (PO)	Jet Propulsion Laboratory	• Provides specific expertise in gravity data sets, sea surface temperature and salinity, ocean surface topography, ocean currents, and circulation	$11.00	31 WYE
Socioeconomic (SEDAC)	Center for International Earth Science Information Network (CIESIN), at Columbia University	• Creates complex, custom datasets from NASA remote sensing products merged with socioeconomic data (e.g,. census data) • Co-located with the Center for International Earth Science Information Network at the Columbia University	4.70	21.2 WYE

Source: NASA OIG analysis of ESDIS documentation.

APPENDIX C: MANAGEMENT'S COMMENTS

National Aeronautics and Space Administration

Headquarters
Washington, DC 20546-0001

FEB 24 2020

Reply to Attn of: Science Mission Directorate

TO: Assistant Inspector General for Audits

FROM: Associate Administrator for Science Mission Directorate

SUBJECT: Agency Response to OIG Draft Report, "NASA's Management of Its Distributed Active Archive Centers" (A-19-002-00)

NASA appreciates the opportunity to review and comment on the Office of Inspector General (OIG) draft report entitled, "NASA's Management of Its Distributed Active Archive Centers" (A-19-002-00), dated January 29, 2020.

In the draft report, the OIG makes three recommendations addressed to the Associate Administrator for Science Mission Directorate (AA/SMD), intended to mitigate the risks associated with the migration to the cloud, improve data management planning, and enhance system security categorizations.

Specifically, the OIG recommends the following:

Recommendation 1: In conjunction with the Earth Science Data and Information System (ESDIS), once Surface Water and Topography (SWOT) and NASA-ISRO Synthetic Aperture Radar (NISAR) are operational and providing sufficient data, complete an independent analysis to determine the long-term financial sustainability of supporting the cloud migration and operation while also maintaining the current DAAC footprint.

Management's Response: NASA concurs with this recommendation and will conduct an independent analysis evaluating the feasibility of maintaining the current Distributed Active Archive Centers requirements and cloud migration activities after 18 months of prime science operations of NISAR and SWOT.

Estimated Completion Date: 3/31/2024.

Recommendation 2: In conjunction with the Earth Science Division, provide comments during the NPR review cycle to the Office of the Chief Engineer for incorporating in both NPR 7120.5E and NPR 7120.8A, language specifying coordination with ESDIS and the Office of the Chief Information Officer (OCIO) early in a mission's life-cycle during data management plan development.

Management's Response: NASA concurs with this recommendation and will provide a recommendation that earlier engagement and coordination among missions, data systems, and the OICO be specified in NPR 7120.5E and NPR 7120.8A during the next NPR update.

Estimated Completion Date: 7/31/2020.

Recommendation 3: In coordination with the OCIO, and during the next security plan review cycle, ensure all applicable information types are considered during system categorization, that appropriate premises are used when determining impact levels, and that the appropriate categorization procedures are standardized across ESDIS systems.

Management's Response: NASA concurs with this recommendation and will continue to work with the OCIO and within the OCIO processes for security plan evaluations and categorizations.

Estimated Completion Date: 6/30/2021.

We have reviewed the draft report for information that should not be publicly released. As a result of this review, we have not identified any information that should not be publicly released.

Once again, thank you for the opportunity to review and comment on the subject draft report. If you have any questions or require additional information regarding this response, please contact Mr. Shea Kearns on (202) 358-0974.

Thomas H. Zurbuchen, Ph.D.

APPENDIX D: REPORT DISTRIBUTION

National Aeronautics and Space Administration

Administrator
Deputy Administrator
Associate Administrator
Chief of Staff
Associate Administrator for Science Mission Directorate
    Earth Science Division
    Earth Science Data Information Systems
Chief Information Officer

Non-NASA Organizations and Individuals

Office of Management and Budget
    Deputy Associate Director, Energy and Space Programs Division

Government Accountability Office
    Director, Contracting and National Security Acquisitions

Congressional Committees and Subcommittees, Chairman and Ranking Member

Senate Committee on Appropriations
    Subcommittee on Commerce, Justice, Science, and Related Agencies

Senate Committee on Commerce, Science, and Transportation
    Subcommittee on Aviation and Space

Senate Committee on Homeland Security and Governmental Affairs

House Committee on Appropriations
    Subcommittee on Commerce, Justice, Science, and Related Agencies

House Committee on Oversight and Reform
    Subcommittee on Government Operations

House Committee on Science, Space, and Technology
    Subcommittee on Investigations and Oversight
    Subcommittee on Space and Aeronautics

(Assignment No. A-19-002-00)