

Earth Science Data Systems Program

Level-of-Service Model

Version 1.0



EARTH SCIENCE
DATA SYSTEMS



1 APPROVALS

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Abstract: Intention and Document Organization

This work has been completed by the NASA Earth Science Data Systems (ESDS) Program and is applicable to all ESDS program components, including the Earth Science Data Information Systems (ESDIS) project, Interagency Implementation and Advanced Concepts Team (IMPACT), and any future program components.

This simple Level-of-Service (LoS) model utilizes the NASA-defined data product category and data processing level to identify the appropriate LOS applicable to a NASA data product throughout the full cycle of data stewardship.

The intended audience for this document is ESDS, including ESDIS management and DAAC personnel. Section 1 introduces the document. Section 2 defines the data product categories. Section 3 includes a table for determining which service level applies to a given data product and provides guidance on service level determination. Section 4 identifies service-level requirements for each service category. Appendix A contains an example of how the LOS concept can be shared with data producers and data users. These examples use clear descriptions of what can be expected at each service level using simple language without jargon to help data producers and data users develop reasonable service expectations for a specific data product in terms they can understand. Appendix B includes a list of roles and expectations for data repositories and data producers that aligns with Section 4.

This LoS model is expected to be ever-evolving in response to feedback from all stakeholders during the review process and once implemented. A change log is included to track these changes.

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2 INTRODUCTION

NASA's Earth Science Data Systems (ESDS) program is responsible for actively managing NASA's Earth science data as a national asset. Through its components – including the Data System Evolution Program, Earth Observing System Data and Information System (EOSDIS) Program, Earth Science Data System Working Groups (ESDSWG), Small Satellite Commercial Data Buy Program, and Standards and Interoperability Coordination and Development – ESDS ensures NASA Earth Science data are accurately and securely ingested, preserved, distributed, and supported. NASA's Earth Science Data and Information System (ESDIS) manages EOSDIS, which is comprised of Science Investigator-led Processing Systems (SIPS), Distributed Active Archive Centers (DAACs), and Land, Atmosphere Near real-time Capability for EOS (LANCE).

With the expansion of digital data and the growing effort and cost associated with managing and preserving data, there is a need for ESDS to accommodate growth in an efficient manner. Yet there is also a need to go beyond the basic role of accepting and archiving data into supporting the vast and varied communities of NASA data users.

Current metadata and format standards allow tools and services to be extended to new or additional datasets and to new user communities. However, tools and services are inconsistently applied to data products and to the user communities that utilize the data. Data users unfamiliar with data product characteristics are often confused about the services that can be expected for a particular product. Given that it is not possible, nor is it always desirable, to provide exactly the same services to all data products, NASA data repositories must appraise incoming data to determine the appropriate service and commitment level for each product.

Service level assignment – determining which service level is appropriate for a given data product – is a necessary first step in supporting consistent access to data. Even the term 'Level-of-Service' is not clearly and consistently defined across all ESDS components. Recent efforts have focused on implementing a more consistent approach and definition (see SE-TIM presentation in which Amanda Leon (NSIDC) and Eric Tauer (PO.DAAC)¹ presented some of the DAAC service level models in use). However, no consistently-applied, enterprise-wide service-level approach existed. This model has been developed to remedy that.

In general, service level is considered as a set of offerings for a given data product. These offerings vary based on conditions that can include DAAC budget, NASA processing level, DAAC or data producer toolkit maturity, expected data users, DAAC/Mission/ESDIS requirements, product category, mission appropriateness, data design quality², user community needs, data producer participation, and publication team schedule.

The Level-of-Service (LoS) model in this document defines Level-of-Service, describes expected service requirements by service level, and outlines a service-level assignment process meant to provide consistent data services across all data repositories. This model is designed to facilitate service-level decision making and provide a transparent and accountable enterprise approach.

Development of this LoS model was informed by the various DAAC service level approaches currently in use. Most have a three-level system in which a higher level implies more services made available at a higher cost and more commitment from the DAAC and data producer. This approach is also utilized here. This document identifies the minimum requirements in alignment with NASA's 'Requirements for Archiving, Distribution and User Services in Earth Observation

¹ SE-TIM Session: [Dataset Level of Service: What is it? Where do we want to go with it?](#), August 29, 2018

² Data design quality includes processing level, format, and metadata completeness that determine data usability

System Data and Information System (EOSDIS)³ (ADURD). ADURD outlines the requirements for the process of data archiving, data distribution, and user services of EOSDIS-supported data. This LoS model does not describe detailed activities, nor does it provide information about how ESDS program components should meet the stated requirements. However, the LoS model may be expanded to point to procedural guides, standards, or requirements that must be followed when implemented.

The **primary goals of the LoS model** are:

- Provide a framework for communicating clear information about the stewardship of NASA Earth science data.
- Use consistent terminology so data producers interacting with multiple DAACs or ESDS program components can understand the process independently of the data center with which they interact.
- Present clear definitions and service level descriptions so all data producers and users can understand how services are assigned and have realistic expectations of LoS effort.
- List common data stewardship requirements by service level. DAAC and project-specific services are not included in the model and would need to be specified separately.
- Improve enterprise-wide transparency, efficiency, and cost-effectiveness of the data stewardship process.

Terminology in this document:

Data product (or dataset or data set, all used here as synonymously) – The files containing data pertaining to a specific instrument, variable or group of variables, or time period. For example, TRMM (TMPA/3B43) Rainfall Estimate L3 1 month 0.25 degree x 0.25 degree V7 (TRMM_3B43). A data product may or may not be included in a particular data collection.

Data collection – All data products related to a project. For example, all data products of a campaign, such as DISCOVER-AQ or Operation IceBridge, or a mission, such as SWOT or CYGNSS.

Data repository – An ESDS component that serves as a custodian of NASA Earth science data, for example NASA's Distributed Active Archive Centers (DAACs). Data repositories process, archive, document, and distribute data from NASA's past and current Earth-observing satellites and field measurement programs.

Services – Activities and tools provided for or used in the process of ingesting, checking, archiving, documenting, and distributing data, as well as actions that support and improve access to, discovery of, inquiry about, and outreach for data after distribution.

Level-of-Service – The total service offerings for a data product in the categories of ingest and archival, documentation, distribution and access, tool availability, user support and outreach, and data stewardship. LoS assignment involves determining what services apply for a given data product.

³ <https://earthdata.nasa.gov/about/esdis-project/esdis-policy/adurd>

3 DATA PRODUCT CATEGORIES AND DEFINITIONS

The LoS model requires determining the category for a given data product. However, because data product category is a programmatic definition, it may be assigned to many related data products (such as all data from an airborne investigation) or to a single data product (such as a MEaSUREs product). Sections 2.1-2.6 describe each data product category. Existing NASA data product examples are provided to aid in selecting the most relevant product category.

3.1 Science Mission Data Products

Science mission data products include data from any mission that supports NASA's core Earth observing system. This includes mission data generated by:

- The Earth Observing System (EOS) program: The EOS program includes coordinated polar orbiting satellites that focus on key Earth science research areas, including the radiation budget, oceans, precipitation, greenhouse gases, aerosols, ozone and stratospheric chemistry, and land-surface hydrology. Example missions include Aqua, Terra, the Landsat series, and Aura (JPSS, S-NPP).⁴
- The Earth Systematic Missions (ESM) program: ESM missions continue to improve understanding of Earth systems. Many of these missions support the 2007 Decadal Survey findings. Example missions include ICESat-2, GRACE-FO, NISAR, and SWOT.⁵
- The Inter-agency Partnership program: These missions are jointly supported by NASA and other Federal agencies, such as NOAA or international partners (ESA, JAXA). Example missions include the GOES series and Sentinel 1, 3, 5P, and 6.⁶
- The Earth System Science Program (ESSP): ESSP missions, many of which are Venture Class, are characterized by innovative design and relatively rapid implementation. These missions focus on important Earth systems components and processes. Example missions include CloudSat and the OCO series.⁷
- The Earth Venture program: Within ESSP, EV missions are science-driven, competitively-selected missions that enhance understanding of the current state of the Earth system. The Earth Venture program has four subprograms: Earth Venture Mission (EVM), Earth Venture Suborbital (EVS), Earth Venture Continuity (EVC), and Earth Venture Instrument (EVI). Example missions include GEDI, CYGNSS, OMG, CORAL, HS3, and TEMPO.⁸
- Other key missions that support NASA's core Earth observing system, including the Precipitation Measurement Missions such as TRMM and GPM core⁹, and A-Train missions, such as GCOM-W1.

Science mission satellite data products are typically generated by the Science Investigator-led Processing Systems (SIPs), Science Data Systems (SDSs), or associated DAAC from raw data supplied by the ground systems. Science mission airborne data products in support of these satellite

⁴ <https://eosps.nasa.gov/mission-category/3>

⁵ <https://eosps.nasa.gov/mission-category/4>

⁶ <https://eosps.nasa.gov/mission-category/10>

⁷ <https://eosps.nasa.gov/mission-category/11>

⁸ <https://eosps.nasa.gov/mission-category/13>; <https://essp.nasa.gov/>

⁹ <https://pmm.nasa.gov/>

missions are generated by the instrument team from the instrument data and are provided to the DAAC as finished data products.

3.2 NASA-funded Data Products

The NASA-funded data products category includes data generated for research and development that support the continual evolution of NASA's Earth science data systems and add to the data records provided by NASA's Earth observing systems. These products are generated outside of the larger NASA science missions (Section 2.1) but are funded by NASA to support the Earth science research community and are deemed to be of significant scientific value to the broader community. These products are developed as a part of NASA-funded projects resulting from programs such as the Making Earth System Data Records for Use in Research Environments (MEaSUREs) program and other NASA Research Opportunities in Space and Earth Sciences (ROSES) solicitations related to Earth science data.¹⁰ The NASA Advancing Collaborative Connections for Earth System Science (ACCESS) program focuses on technology improvement, but may also generate a limited number of value-added products that transform data to more user-friendly formats or projections. Products may also be funded by other NASA Earth Science Division programs, such as NASA's Terrestrial Ecology Program. Examples include Global Forest Cover Change Multi-Year¹¹ data products, Goddard Satellite-Based Surface Turbulent Fluxes data products, and LANDMET data products¹². Other examples include data generated from the ABoVE¹³ and BigFoot¹⁴ campaigns.

3.3 Facility-created Data Products

The facility-created data products category includes products created outside of science mission or ROSES funding mechanisms. This category may include data products created to support the integration of socioeconomic and Earth science data¹⁵ or airborne and field campaign ancillary data funded outside of traditional NASA funding pathways. These data products may include algorithm or validation investigations in support of science missions if these investigations are not funded through the science mission or other NASA-funded programs. Investigation data collections can be very heterogeneous and may include non-NASA support data provided by other agencies or data partners as part of the investigation. Therefore, facility-created data products may have widely-varying service levels. Data from special field investigations, research products, and experimental sensors fall into this category. Examples include data products from PICARD¹⁶, GLISTIN¹⁷, AIRMOSS¹⁸, and HyTES¹⁹.

3.4 NASA Research Community Data Products

This category contains all data for which the data producer initiates a request for archival and includes data products generated by research scientists using NASA data. In this case, the data

¹⁰ <https://science.nasa.gov/earth-science/earth-science-data/open-solicitations-earth-science-data-systems/>

¹¹ <http://dx.doi.org/10.5067/MEaSUREs/GFCC/GFCC30FCC.001>

¹² <https://search.earthdata.nasa.gov/search?fpj=MEaSUREs>

¹³ https://daac.ornl.gov/cgi-bin/dataset_lister.pl?p=34

¹⁴ https://daac.ornl.gov/cgi-bin/dataset_lister.pl?p=1

¹⁵ <http://sedac.ciesin.columbia.edu/about>

¹⁶ <https://airbornescience.nasa.gov/instrument/PICARD>

¹⁷ <https://airbornescience.jpl.nasa.gov/instruments/glistin>

¹⁸ https://daac.ornl.gov/cgi-bin/dataset_lister.pl?p=36

¹⁹ <https://hytes.jpl.nasa.gov/>

producer was not directed to submit data for NASA archival as part of any funding conditions, and therefore Completion of an archival request is required. A request must be submitted to the appropriate data repository and reviewed for recommendation by the User Working Group and approved by ESDIS before the data can be accepted. Such requests are typically accepted if the data product is relevant to NASA Earth Science and the thematic area of the data repository and is valuable to the thematic user community and the broader Earth science community. Examples of NASA research community data products include the Arctic Sea Ice Melt Season Climate Indicators²⁰, OSCAR ocean surface currents²¹, and Global Gridded Soil Phosphorus Distribution Maps²².

3.5 NASA Applied Science Data Products

The NASA Applied Science program occasionally produces data products deemed as providing valuable information to a broad NASA audience. These data products must meet basic data quality standards to ensure they are suitable for use, distribution, and long-term storage. They must also support the ESDS programmatic commitment of ensuring NASA's Earth observation data are openly available for interdisciplinary study and use. Data products not aligned with this commitment and not related to NASA's Earth observation data are not considered. This category does not include data products without programmatic commitment. Examples of NASA applied science data products include the Global Fire Emissions Database²³, Global Database of Soil Respiration²⁴, and Sediment Analysis Network for Decision Support (SANDS) Landsat GeoTIFF²⁵ data products. These data products typically undergo the data product approval process, which requires User Working Group recommendation and ESDIS approval.

3.6 Non-NASA Research Community Data Products

This category includes other data products generated by the research science community without NASA funding, but that also fit NASA's Earth Science mission. A request for archival is initiated by the data producer and requires completing the data archive User Working Group and ESDIS archival review process. These data products must be relevant to the thematic area of a specific data repository and useful to its user community. For example, sea ice data from a non-NASA producer may be useful for comparison with NASA data products distributed by NSIDC DAAC. Additionally, such products do not necessarily need to leverage NASA's Earth observation data. Examples of non-NASA research community products include the Alaska Tidewater Glacier Terminus Positions²⁶, and the LiDAR-derived Vegetation Canopy Structure, Great Smoky Mountains National Park²⁷.

²⁰ <https://nsidc.org/data/nsidc-0634/versions/1>

²¹ <http://dx.doi.org/10.5067/OSCAR-03D01>

²² http://daac.ornl.gov/cgi-bin/dsvviewer.pl?ds_id=1223

²³ <https://dx.doi.org/10.3334/ORNLDAAC/1293> <https://doi.org/10.3334/ORNLDAAC/1293>

²⁴ <https://dx.doi.org/10.3334/ORNLDAAC/1578> <https://doi.org/10.3334/ORNLDAAC/1578>

²⁵ <http://dx.doi.org/10.5067/SANDS/TM/DATA101>

²⁶ <http://dx.doi.org/10.5067/3OOVUDEFK3R0W>

²⁷ <https://dx.doi.org/10.3334/ORNLDAAC/1286> <https://doi.org/10.3334/ORNLDAAC/1286>

4 MAPPING PRODUCT CATEGORY AND PROCESSING LEVEL TO LEVEL-OF-SERVICE

This LoS model sets the level-of-service separately for each data product, even if it is part of a data collection. Taken together, the data product category and the [NASA data processing level](#)²⁸ are used to identify the LoS to be applied. Therefore, individual data products within the same data collection can have different service levels. The data processing level is a necessary consideration for data archival as it relates directly to the effort needed for data intake, storage, publication, distribution, and support.²⁹ Another factor affecting service needs includes the expectations of the user community, which is related to the product category.

This LOS model utilizes **three service levels**: basic, standard, and comprehensive. Each service level implies a typical user community and the services that community may expect.

- *Basic*: Limited user community, likely more skilled and self-sufficient users, or data of lower processing level that may not be used by many users.
- *Standard*: Targeted data user communities requiring technical services to utilize the data for research.
- *Comprehensive*: Broad user community with a greater need for data visualization tools, user support, and/or education, in addition to the more technically skilled and scientific users seeking analysis-ready data outside their field.

The LOS Assignment table (Table 1) includes **six data processing levels**, including two levels not defined in the NASA data processing list¹³. One of these extra levels is for the Auxiliary and Ancillary data products that are often part of a mission or an airborne or field investigation data collection. While not necessarily produced by NASA, these data products need to be published, usually at a basic service level. The second is for Near-Real Time (NRT) data, which is included to address the need for the additional services often required by such data. Although an NRT data product may have a comprehensive service level designation due to its product category and processing level, it may not obtain all comprehensive level services as some may not apply and others may not be realistic.

This LoS model is used in decision-making when applying service resources to data products and is meant to bring enterprise-wide consistency to service level decisions. The service requirements listed in this model should be applied to a given dataset at the appropriate service level. If cost, resources, or data producer preparation and participation limit the services that can be offered, the data repository can provide the services of the next lower level with ESDS guidance.

As with any model, some exceptions are expected and, on occasion, data product complexities and time/resources may need to be taken into account. In such cases, it is vital to identify the reasons for the alternative service level assignment. Accounting for differences provides a means for improving the LoS model to address frequently needed alternative assignments.

²⁸ <https://science.nasa.gov/earth-science/earth-science-data/data-processing-levels-for-eosdis-data-products>

²⁹ <https://www.archives.gov/records-mgmt/initiatives/appraisal.html>

Table 1: Level of Service Assignment

		Data Product Category					
		Science Mission Product	NASA-Funded Data Products	Facility Created Product	NASA Research Community Product	NASA Applied Science Product	non-NASA Research Community Product
Data Processing Level	Raw Data (L0)	Basic	N/A	N/A	N/A	N/A	N/A
	Calibrated Data (L1A/L1B)	Standard	Basic	N/A	Basic	N/A	N/A
	Swath Data (L2)	Comprehensive	Standard	Standard	Standard	Standard	Standard
	Gridded Data (L3/L4)	Comprehensive	Comprehensive	Comprehensive	Comprehensive	Standard	Standard
	Auxiliary/Ancillary Data	Standard	Basic	Basic	Basic	Basic	Basic
	NRT Data** ³⁰	Comprehensive	N/A	Comprehensive	Standard	Standard	N/A

5 LOS MODEL SERVICE LEVEL REQUIREMENTS

The LoS model describes the minimum expected requirements for the **six service categories**: Ingest, Check, and Archive (Section 4.1); Distribution and Access (Section 4.2); Documentation (Section 4.3); Discoverability and Usability (Section 4.4); User Support and Outreach (Section 4.5); and Preservation (Section 4.6). Each service category section includes a work category description and a table of the required services at each identified service level. Each service level includes the requirements of the previous level(s) plus those listed for that level. The basic LOS requirements reflect functional capabilities defined in NASA’s ‘Requirements for Archiving, Distribution and User Services in Earth Observation System Data and Information System (EOSDIS)’³¹.

The model specifies the LoS requirements rather than suggesting how those requirements should be met. While many of the service categories deal with data publication (or the act of accepting, archiving, and making data publicly available), not all service categories involve this type of work. The Documentation, Discoverability and Usability and User Support and Outreach categories include services that continue beyond data publication and focus on work not necessarily associated with any one data product. Requirements in these categories apply to upcoming/future datasets and data archiving efforts. LOS requirements are initially not applied to data already available through a data repository.

³⁰ ** Near Real-Time (NRT) data are considered to have specific needs beyond those of other published data. NRT data are primarily only relevant for consideration when part of a science mission product.

³¹ <https://earthdata.nasa.gov/about/esdis-project/esdis-policy/adurd>

5.1 Ingest, Check, and Archive

The Ingest, Check, and Archive category includes services for the first stage of data publication work, which is performed upon receipt of a data product and ensures the data product is accurately and completely obtained from the data producer and safely archived. Some data repositories use the term “operations” for this type of work. The actual workflow may differ at each data repository, but the service level requirements should be fulfilled through this activity. Most of the category requirements are relevant to all service levels. Some definitions consider *ingest* to include the act of making the data publicly available with metadata available in the Common Metadata Repository (CMR). Under this LOS model, those steps are considered to be in a separate category, Distribution and Access (Section 4.2).

Ingest, Check, and Archive	
Level-of-Service	Service Level Requirements
Basic	<ul style="list-style-type: none"> ✓ Obtain data from data producer via download or delivery ✓ Confirm file number and file size ✓ Confirm accurate data transfer using checksums for delivered data ✓ Confirm data access (can read files without read error) ✓ Apply a standardized file name to meet ESDS policies ✓ Place data in a standardized data directory structure ✓ Check file format for consistency and usability ✓ Produce an archive copy of data product and routinely verify replacement³² ✓ Perform technology updates to continue safe data storage and access ✓ Provide ingest metrics to the ESDIS Metrics System (EMS)
Standard	<ul style="list-style-type: none"> ✓ Check data for incomplete or inaccurate (outside stated range) data and work with data producer to improve content to standard³³ or replace ✓ Check file format for standard compliance, change as needed
Comprehensive	<ul style="list-style-type: none"> ✓ No additional requirements at this level

5.2 Distribution and Access

The Distribution and Access service category includes placing the data in a public location (distribution) and ensuring the data files are findable by the targeted communities (access). At the most basic level, services include placement of the data on a public server and obtaining a Digital Object Identifier (DOI) for the data product that resolves (or links) to a permanent data product landing page. Data distribution ensures a data product is openly and freely available within the agreed upon time period. Data deemed valuable to rapid scientific assessment and decision-making

³² The concept “verify replacement” implies the data repository will routinely confirm the archive copy can accurately be used to replace the public copy of a data product in the event it is needed within a reasonable period.

³³ Many data repositories see it as the responsibility of the data producer to check data for incomplete or out-of-range values, however, this model advises data repository personnel confirm that data presentation is clear to the user. That is, the data repository must check if data values are within a stated data range or are within reasonable limits, or that the ASCII file contains only numbers and text, no asterisks. There is currently no standard regarding data content quality and representation. Development of an enterprise best practice is advised.

may also be distributed in near-real time (NRT). Data access includes providing data products in machine services and visualization tools so they are accessible to machines and humans.

Distribution and Access	
Level-of-Service	Service Level Requirements
Basic	<ul style="list-style-type: none"> ✓ Place data on public server within the expected time frame ✓ Confirm access to data via HTTPS ✓ Obtain DOI that redirects to a landing page with required product information ✓ Provide data distribution metrics to EMS
Standard	<ul style="list-style-type: none"> ✓ Make data available for machine services (such as OPeNDAP and THREDDS per NASA standards), where appropriate ✓ Provide browse images, if available for data product ✓ Develop code for NRT data distribution, if needed ✓ Provide data collocated with compute (i.e., cloud technologies), if possible
Comprehensive	<ul style="list-style-type: none"> ✓ Provide specialized data access capabilities (e.g., scripting, machine to machine) ✓ Ensure data transfer integrity by providing checksums to users as needed ✓ Provide data use metrics to the data producer ✓ Make NRT data available in LANCE

5.3 Documentation

Good documentation promotes understanding and correct use of the data, lowers barriers to data use, and supports data sharing and re-use. Data repositories are responsible for ensuring that distributed data are fully and precisely documented. The documentation service category includes the collection, organization, and creation of materials needed for users to properly understand and utilize the data. Documentation describes the structure and field names in files, provides context about why the data product was created, explains any processing performed, and details product history. At higher service levels, the process of data product document creation may consist of searching for additional materials containing methodology or accuracy information, if such materials are not supplied by the data producer. Basic documentation needs to be human- and machine-readable. This category also contains many human-performed actions, including verifying metadata, creating metadata as needed, and assessing supplied information for clarity.

Documentation	
Level-of-Service	Service Level Requirements
Basic	<ul style="list-style-type: none"> ✓ Create collection metadata and verify data file metadata accuracy ✓ Construct and confirm data product citation

	<ul style="list-style-type: none"> ✓ Construct simple user guide describing the data product and containing summary information such as spatial and temporal metadata and platform/instrument source ✓ Create data product landing page and check for accuracy
Standard	<ul style="list-style-type: none"> ✓ Assign data product variable and services metadata ✓ Complete detailed user guide containing methodology and quality assessment information following a standard guide format ✓ Review data producer documentation for clarity and improve as needed ✓ Capture ATBD and software for distribution to users ✓ Adhere to ESDIS metadata requirements and implement needed changes
Comprehensive	<ul style="list-style-type: none"> ✓ Check and improve all metadata to increase data usability ✓ Create data recipes, annotated read routines, or data notebooks ✓ Create micro articles or 'Data in Action' web content to increase data use ✓ Develop specific web pages to introduce the project or instrument to a broader audience ✓ Locate and add links to metadata of relevant data-related publications ✓ Add additional details to the user guide such as validation summaries, publication references, applications, or example uses

5.4 Discoverability and Usability

The Discoverability and Usability category includes actions performed to ensure that data can be easily located and used by data users. Making data discoverable allows users to search for, locate, select, and obtain data. At the minimum level, discoverability requires complete and accurate metadata in the Common Metadata Repository (CMR), which allows data to be located using the Earthdata Search client. At higher service levels, actions that allow for improved discoverability may include ensuring the data are available to other web-accessible services. Usability involves verifying that data are easily used by the targeted user communities or by a broad audience. As part of their responsibilities, data repositories must assess how easy it is to locate and obtain data and how easily the data can be used in various standard tools³⁴. The goal is to make data easier to use by promoting interoperability across data formats, services and tools. Standardized data structures and services also make data more discoverable and usable for data users.

Discoverability and Usability	
Level-of-Service	Service Level Requirements
Basic	<ul style="list-style-type: none"> ✓ Confirm published metadata comply with accepted standards ✓ Publish required collection and file (granule) metadata in CMR ✓ Provide necessary data search and access capabilities ✓ Confirm the data product can be located by search

³⁴ <https://earthdata.nasa.gov/earth-observation-data/tools>

	<ul style="list-style-type: none"> ✓ Confirm a user can access the landing page, the data product user guide and any producer documentation or publications via the landing page
Standard	<ul style="list-style-type: none"> ✓ Report additional service and variable metadata in CMR ✓ Publish data in an ESDIS Standards Office approved format³⁵ ✓ Confirm data are usable in standard analysis tools³⁶ ✓ Produce browse imagery for data product if not provided by data producer (and add a link to metadata for browse image access) ✓ Provide advanced search capabilities through Earthdata Search³⁷ ✓ Provide basic subsetting and reformatting services
Comprehensive	<ul style="list-style-type: none"> ✓ Add data browse imagery to Worldview/GIBS ✓ Add data product access to appropriate micro articles, website content, or curated virtual collections ✓ Provide advanced subsetting, reprojection, reformatting, or resampling services ✓ Provide data in a format popular with a broader audience, such as GeoTIFF for GIS users ✓ Develop special visualization tools as needed for targeted users ✓ Develop higher level products such as gridded or merged products from swath data to make data more useful to a broader user community, as needed

5.5 User Support and Outreach

ESDS components are stewards of the data they publish. As such, ESDS components must support data users and provide assistance with data use and applicable tool and service utilization. In addition, data repositories need to promote scientifically relevant data to the broader Earth science community for the higher service-level data products (outreach). Data repositories are advised to select the appropriate and needed services from the comprehensive category rather than assume all services are required.

User Support and Outreach	
Level-of-Service	Service Level Requirements
Basic	<ul style="list-style-type: none"> ✓ Publicly announce data product publication ✓ Assist data users with data access and user question responses via a user forum and/or question management software ✓ Maintain and keep website and data landing page information current

³⁵ List of approved formats is available at <https://earthdata.nasa.gov/user-resources/standards-and-references>

³⁶ EOSDIS Standards Office is encouraged to maintain a list of appropriate/approved standard analysis tools, such as Panoply, IDL, MatLab, GRIB, Python, and others for use in reading and utilizing NASA Earth science data files.

³⁷ Some DAACs have their own search client. All are advised to implement Earthdata Search and work toward improving their advanced capabilities.

Standard	<ul style="list-style-type: none"> ✓ Assist users with machine services and other analysis tools ✓ Broadly announce and highlight the data product, perhaps via a feature article or website news article ✓ Communicate data quality to data users and assist users with appropriate use
Comprehensive	<ul style="list-style-type: none"> ✓ Highlight data at conferences such as NASA hyperwall flash talks, conference poster/session talks ✓ Highlight the data in Earthdata Mastheads ✓ Highlight the data in NASA Webinars and/or YouTube videos ✓ Include the data in outreach materials for general users, including possible ESRI Story Map or Google Voyager story ✓ Provide subscription feeds in a manner consistent across NASA enterprise including updates to data products or new version releases ✓ Collaborate with NASA's Earth Observatory webpage to highlight the data ✓ Interact with and support science teams associated with the data products

5.6 Preservation

All NASA data repositories are mandated to safely preserve the data and associated information and software for the data they steward. In the cloud-based future, this may mean confirming that preservation is maintained and tested, as the actual storage would consist of the cloud-storage provider backup systems. The data preservation process promotes longevity, safety, and integrity by ensuring the data are not compromised over time. All preservation activities adhere to requirements outlined in the NASA Earth Science Data Preservation Content Specification document³⁸. Preservation includes the creation or arranging of data backups for easy replacement and the gathering of extensive documentation to be publicly preserved in an organized, accessible manner. Preservation activities also include obtaining and storing software code and important related journal publications that provide algorithm or data quality information from data producers. In time, all public NASA data will fully meet these preservation requirements, not just data at the highest levels of service. Preservation does not apply to near-real time data (which do not require preservation services by the nature of the data) or to non-NASA data products (for which NASA is not responsible).

Preservation	
Level-of-Service	Service Level Requirements
Basic	<ul style="list-style-type: none"> ✓ Maintain a permanent DOI and landing page ✓ Archive final version of data product ✓ Verify integrity of data product backup and confirm successful replacement of public copy at regular intervals ✓ Provide permanent access to metadata/product history ✓ Maintain data product metadata to adhere to ESDIS standards

³⁸ <https://earthdata.nasa.gov/user-resources/standards-and-references/preservation-content-spec>

	<ul style="list-style-type: none"> ✓ Locate and add new data validation publications to metadata/landing page/preservation materials ✓ Adhere to any ESDIS metadata changes (CMR)
Standard	<ul style="list-style-type: none"> ✓ Maintain older versions of data product as appropriate ✓ Archive and provide methodology/ATBD, software, and validation results
Comprehensive	<ul style="list-style-type: none"> ✓ Provide complete and organized preservation documentation to the public³⁹ ✓ Transition data formats as they evolve and change

³⁹ This does not mean that a standard LoS data product may not have preservation documentation, only that it is *required* for the comprehensive level to make it public in a logically organized and accessible fashion.

Appendix A Communicating the LoS Model to Data Producers and Data Users

Data publication services information must be communicated differently to data producers and data users. A clear and succinct approach developed by NSIDC DAAC was used as a template for the service level description materials presented here⁴⁰. This written information clearly details the differences between the three service levels. However, data producers or data users perusing data through the Earthdata Search cannot automatically know the service level for any discovered data product because there is currently no service level metadata element included with data.

NASA data repositories are advised to provide users with access to the mapping table in Section 3, and to provide the product category and data processing level descriptions on their web site to enable users and producers to assess what services to expect. Adding the applied service level and data product category to required CMR collection-level metadata elements would provide data producers and data users the information needed to understand the services available for any given data product.

Level-of-Service materials for data producers and data users are provided below. This information is essentially the same as that provided in the LoS model (Section 4). The difference is in the language and approach used to communicate the information to data users and data producers.

Data Producer and Data User Service Level Descriptions

Basic Level-of-Service

At the Basic level, with respect to Data, the Data Repository will...

- Assist with data download or delivery
- Verify file size, file number, file access
- Check file name, file structure, and file description for consistency and accuracy
- Confirm accurate data transfers using checksums, as needed
- Provide Digital Object Identifier (DOI) that resolves to a data product information page (also called a “landing page”)
- Make data available on a public server in a reasonable time frame
- Confirm data are accessible via search services and from a data product landing page link
- Produce an archived copy and confirm accurate replacement in event of system failure
- Preserve related documentation and software, as available
- Update technology to continue safe storage and delivery of data into the future
- Provide metrics to NASA ESDIS

At the Basic level, with respect to Documentation, the Data Repository will...

- Verify and publish basic, accurate metadata (includes geospatial, temporal, and science variable information)
- Provide citation and DOI-resolvable landing page content

⁴⁰ <https://nsidc.org/the-drift/2018/07/adding-clarity-to-nsidc-data-support-with-new-level-of-service-los-model/>

- Produce a simple user guide containing data summary and links to external documentation
- Provide permanent access to data information

At the Basic level, with respect to User Support and Outreach, the Data Repository will...

- Provide users assistance with data access and basic data use questions
- Announce data publication via web and social media
- Maintain website information for as long as data are archived

Standard Level-of-Service

At the Standard level, the Data Repository will provide all Basic Data Services, plus...

- Check file format for standard compliance and aid with adjustment if needed
- Publish more complete metadata, as needed
- Check data for incomplete or inaccurate values and work with data producer to improve
- Make data available to common subsetting and reformatting tools and machine services, such as OPeNDAP, and verify usability of data in such tools
- Publish data browse images from producer or create with producer assistance, as appropriate
- Develop code for near-real time distribution, if appropriate
- Publish data to cloud server for cloud analysis and use, if available
- Provide advanced search capabilities through Earthdata Search

At the Standard level, the Data Repository will provide all Basic Documentation Services, plus...

- Provide a more detailed user guide, including methodology and data accuracy sections
- Assign more detailed metadata (services and variable metadata) in standard format
- Review any data producer-provided documentation for clarity
- Provide users with algorithm description documents and processing software, as needed
- Add data validation publication links to the metadata as they become available over time

At the Standard level, the Data Repository will provide all Basic User Support and Outreach Services, plus...

- Broadly announce data publication to reach more user communities
- Provide data users with assistance and direction to FAQs or user forum, as needed
- Assist users with machine services and other analysis tools
- Communicate data quality to data users and assist users with appropriate use
- Highlight data use on web page or in articles

Comprehensive Level-of-Service

At the Comprehensive level, the Data Repository will provide Basic and Standard Data Services, plus...

- Provide data transfer checksums to users
- Provide data format translation to serve a broader community
- Provide specialized services to subset, reproject, reformat, or resample data
- Add metadata to data, as needed, to increase data discovery and use
- Develop analysis/decision-ready data products more suitable to a broad community
- Add data to NASA GIBS/Worldview and other enterprise-wide tools
- Provide additional specialized data access or use tools
- Make near-real time data available in NASA LANCE
- Provide data producer with data usage metrics
- Include data in relevant virtual collections
- Transition data formats, as needed, to evolve with tool capabilities and standards

At the Comprehensive level, the Data Repository will provide all Basic and Standard Documentation Services, plus...

- Develop additional descriptive or informational materials applicable to more user communities to increase data use
- Develop data recipes or provide open source software help
- Add links on landing page or data product information page that direct users to new data quality publications highlighting scientific findings regarding data.
- Increase linkages to internal/external web pages or documents that may improve data access
- Publicly provide all preservation documentation in an organized manner

At the Comprehensive level, the Data Repository will provide all Basic and Standard User Support/Outreach Services, plus...

- Provide users with assistance for complex problems and direct users to experts, as needed
 - Highlight data in various outreach materials
 - Highlight data in NASA materials, at conferences, in NASA presentations, and in webinars
 - Develop higher-level visualization tools for targeted user communities
 - Provide subscription services to inform users of data product changes or new versions
 - Interact with and support science teams during and after mission or investigation
-

Appendix B Data Publication Roles and Expectations

The lists below outline the anticipated roles and expectations for Data Repositories (Table B.1) and Data Producers (Table B.2). The lists were developed in partnership with the Earthdata Publication effort, which is working to bring a common language and consistent approach to data publication. These lists are drafts and represent a best effort (as of September 2019) to outline roles and responsibilities. The lists demonstrate the good data product stewardship partnership between the data archive and data producer. Each list is organized by specific subcategories of effort, where applicable. The lists are provided to guide Data Producers and Data Repositories and data repositories share the lists with data producers.

B.1 Data Repository Roles and Expectations

These lists describe what is expected of a Data Repository during the data publication process and what the Data Repository can expect from the Data Producer.

With regards to Data Publication and Continued Support, the Data Repository will ...

Data Product Assignment to Data Repository

- Complete the data product approval process if it is a product requested by the community
- Complete and submit a proposal for selection if the data product is to be assigned to a Data Repository (such as for Mission assignment)
- Complete and submit the Data Repository DMP or Implementation Plan once a mission/data product has been assigned (comprehensive service level only)

Communication

- Respond to questions from data producers in a reasonable time frame
- Communicate with data producer throughout the data publication process to verify information accuracy
- Provide data producer with routine data use metrics (comprehensive service level only)

Data Product Delivery/Data Handling

- Provide a point-of-contact for data delivery and ensure the data transfer is convenient, accurate, and easy
- Perform file checks that include transfer accuracy, format consistency/compliance, and data file quality (i.e., missing data checks) as soon as the data product is received
- Adjust file names and data directory structure as needed to meet standards and improve data access and usability
- Ensure quality collection/file level metadata exist that are consistent, meet the designated service level standard, and maintain that metadata quality over time
- Provide data product files and documentation on a public server, discoverable by Earthdata Search, and available for bulk download within an appropriate time frame
- Ensure the data are archived and can be easily replaced in a reasonable time frame
- Ensure the data are accessible and usable over time

Data Publication Process

- Develop a user guide appropriate to the data product service level
- Publish or create browse imagery appropriate to the data product service level
- Make data producer-supplied documentation available to users and check the documentation for clarity (higher service levels only)
- Assign a unique identifier to the data product that resolves to a permanent landing page with required content, and check landing page content for completeness and accuracy
- Confirm data are discoverable in CMR
- Announce data publication to user communities
- Confirm data are accurately portrayed in standard tools appropriate to data service level
- Follow retirement protocol should the data be replaced or become obsolete

Outreach and User Services

- Provide user support with subject matter expert help, as needed (support varies by service level)
- Develop needed software support or education materials (higher service levels only)
- Highlight comprehensive service level data in NASA webinars, science conference posters, and presentations

The Data Repository can expect the Data Producer to...

- Assign a point-of-contact for Data Repository interaction
- Respond to questions in a reasonable time frame
- Submit a detailed data description and sample file(s) at earliest availability
- Work with Data Repository personnel to ascertain file accuracy after data transfer
- Fix any identified in-file metadata or file format compliance issues
- Provide access to appropriate documentation about data product and methodology
- Review materials curated by Data Repository personnel and provide feedback and assistance
- Review outreach materials and check landing page/data product information page content for accuracy
- Provide updated data quality information as it becomes available from scientific use
- Provide any other scientific insight and guidance related to the data product, as needed

B.2 Data Producer Roles and Expectations

These lists describe what is expected from a Data Producer during the data publication process and what the Data Producer can expect from the Data Repository.

With regards to Data Publication and Continued Data Support, the Data Producer will...

After Data Repository Assignment and Before Project Begins

- Complete the Data Management Plan (DMP) for Data Producers within designated time frame. If the data not assigned to a Data Repository, complete the archive interest form.
- Provide data description(s) and sample file(s) to the Data Repository, as defined in the DMP
- Share relevant documentation, such as project plan or science plan, to help the Data Repository prepare for data publication

Communication

- Respond to questions in a reasonable time frame
- Provide a Point-of-Contact to the Data Repository for future data questions/issues

Data Delivery/Data Handling

- Provide sample files before data product delivery
- Deliver data and checksum files to Data Repository in a reasonable time frame and assist with any delivery problems
- Add complete metadata to files per standard format
- Check file metadata compliance prior to data delivery using suggested tools and utilize Data Repository expertise to improve metadata quality, as needed

Data Publication

- Submit descriptive metadata using online form
- Review Data Repository curated user guides for accuracy
- Deliver associated algorithms, scripts, or code used to develop the product for standard and comprehensive service level data products
- Provide read routines for data that are not in a self-describing format
- Provide access to appropriate documentation about data product quality and production methodology (standard and comprehensive service levels)

Data Product Outreach and User Services

- Review specialized outreach materials before distribution (comprehensive service level)
- Provide Data Repository with updated data quality information as it becomes available
- Promote Data Repository-published data by using Data Repository data citation and DOI
- Provide subject matter expertise (SME) for the data products

The Data Producer can expect the Data Repository to ...

- Provide a Point-of-Contact for help and questions
- Respond to questions in a reasonable time frame
- Assist with understanding metadata requirements and assigning metadata
- Help with checking data format and metadata compliance
- Confirm files have transferred without error
- Check files for usability
- Assign the data a DOI that resolves to a permanent landing page hosted at the Data Repository
- Communicate throughout the data publication process and provide updates
- Request review of data product guide, landing page, data product information page, and any outreach materials
- Publish the data in a reasonable time frame
- Support data access, safety, and usability into the future