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DSMR-00266 Version 1.0

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Data Stewardship Maturity Report for GHRSST Level 4 MUR Global Foundation Sea Surface Temperature Analysis (v4.1) (GDS versions 1 and 2)

Table 1 Legend				
Level 1	Level 2	Level 3	Level 4	Level 5
Ad Hoc	Minimal	Intermediate	Advanced	Optimal
Little or no management	Limited Management	Defined Management, partially implemented	Well-defined Management, fully implemented	Full Management, audited, measured, controlled

Table 1. Scores for the Nine DSMM Key Components at a Glance		
Preservability - 5	Accessibility - 5	Usability - 4.5
Production Sustainability - 5	Data Quality Assurance - 4	Data Quality Control/Monitoring - 4.5
Data Quality Assessment - 4.3	Transparency/Traceability - 4	Data Integrity - 4

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U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Environmental Satellite, Data, and Information Service

Cover Image: Data Stewardship Rating Diagram for GHRSST Level 4 MUR Global Foundation Sea Surface Temperature Analysis (v4.1) (GDS versions 1 and 2)

Shades of green are used to represent level 1 through level 5 ratings; denoting Ad Hoc, Minimal, Intermediate, Advanced, and Optimal stages for each of the nine key components, respectively. The dark green level indicates all the practices are completely satisfied. The lighter green levels indicate only some of the practices are satisfied. The lightest green level indicates none of the practices are satisfied.

The stewardship maturity of NCEI data product, GHRSST Level 4 MUR Global Foundation Sea Surface Temperature Analysis (v4.1) (GDS versions 1 and 2), is assessed based on a reference stewardship maturity framework. The current maturity ratings of GHRSST Level 4 MUR Global Foundation Sea Surface Temperature Analysis (v4.1) (GDS versions 1 and 2) are at Level 1 or higher for all nine key components with zero Level 1, zero Level 2, zero Level 3, six Level 4, and three Level 5 key components.

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The National Environmental Satellite, Data, and Information Service (NESDIS) manages the Nation's civil Earth-observing satellite systems, as well as global national data bases for meteorology, oceanography, geophysics, and solar-terrestrial sciences. From these sources, it develops and disseminates environmental data and information products critical to the protection of life and property, national defense, and the national economy, energy development and distribution, global food supplies, and the development of natural resources.

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ASSESSMENT REVISION HISTORY

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Data Stewardship Maturity Report for GHRSST Level 4 MUR Global Foundation Sea Surface Temperature Analysis (v4.1) (GDS versions 1 and 2)

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Preface

In response to the President's Open Government Initiative and related policies, NOAA has committed to providing improved public access to all of its environmental information, to enable research and commercial innovation through ease of data discovery and use [*Casey*, 2016].

OneStop supports NOAA's efforts by leveraging existing access technologies and infusing specific innovations to provide improved discover, access, and visualization services for NOAA's data. Also, OneStop is viewed by a NESDIS as a pathfinder effort with an initial focus on selected high-priority datasets from NESDIS and other program data meeting OneStop standards, but eventually scalable across NOAA's data. Lastly, OneStop is implementing the USGEO Common Framework for Earth Observation Data and leveraging/supporting the NOAA Big Data Project (BDP) and Big Earth Data Initiative (BEDI) [*Casey*, 2016].

As with any process of improvement planning, agencies need to find out where they are in terms of their compliance to the federal regulations and what they need to do if any areas of non-compliance are identified. To this end, a unified framework would be beneficial for assessing the current stage of stewardship practices applied to individual datasets and for providing a road map that will guide future investments towards enhanced stewardship of environmental datasets. The value and quality of a dataset depends in part on the stewardship practices applied after its development and production. Therefore, a unified framework providing a holistic view of the quality of stewardship practices applied to individual datasets is beneficial to data stewards and users [*Casey*, 2016].

The Data Stewardship Maturity Matrix (DSMM), jointly developed by domain (data management, technology, and science) subject matter experts from NOAA's National Centers for Environmental Information (NCEI) and Cooperative Institute for Climate and Satellites – North Carolina (CICS-NC), provides such a consistent framework [*Peng et al.,* 2016]. The DSMM, leveraging institutional knowledge and community practices and standards, defines a graduated maturity scale for each of nine key components of scientific data stewardship to enable a consistent assessment of the measureable stewardship practices applied to a given data set or product.

The NOAA Data Stewardship Maturity Technical Series captures stewardship maturity assessment results for individual datasets, provides consistent representation and citable documents of those assessments, ensures transparency, and allows better data quality information integration and content-based search and discovery of NOAA data.

NOAA Technical Information Series NESDIS DSMR-00266 Version 1.0

Data Stewardship Maturity Report for GHRSST Level 4 MUR Global Foundation Sea Surface Temperature Analysis (v4.1) (GDS versions 1 and 2)

1. Introduction

1.1 Purpose

The purpose of this document is to describe the results of stewardship maturity assessment for NOAA Climate Data Record for Mean Layer Temperature (Upper Troposphere & Lower Stratosphere from UCAR, Version 2, utilizing the Scientific Data Stewardship Maturity Matrix or DSMM [Peng, et al, 2016]. DSMM defines levels of stewardship maturity stages for Preservability, Accessibility, Usability, Production Sustainability, Data Quality Assurance, Data Quality Control/Monitoring, Data Quality Assessment, Transparency/Traceability, and Data Integrity key components. Each of these components is ranked from 'Ad hoc' to 'Optimal' (see Appendix I). This report is based on evaluation performed by NOAA OneStop metadata specialists working with Subject Matter Experts and utilizing the DSMM template [Peng, 2016].

1.2 Scope

Assessing stewardship maturity - the current state of how datasets are documented, preserved, stewarded, and made accessible publicly, is a critical step towards meeting U.S. federal regulations, organizational requirements, and user needs [Peng et al., 2016]. The goal of this document is to provide consistent and transparent stewardship maturity information to data users and decision-makers.

1.3 Dataset Abstract

A Group for High Resolution Sea Surface Temperature (GHRSST) Level 4 sea surface temperature analysis produced as a retrospective dataset (four day latency) and near-real-time dataset (one day latency) at the JPL Physical Oceanography DAAC using wavelets as basis functions in an optimal interpolation approach on a global 0.01 degree grid. The version 4 Multiscale Ultrahigh Resolution (MUR) L4 analysis is based upon nighttime GHRSST L2P skin and subskin SST observations from several instruments including the NASA Advanced Microwave Scanning Radiometer-EOS (AMSR-E), the JAXA Advanced Microwave Scanning Radiometer 2 on GCOM-W1, the Moderate Resolution Imaging Spectroradiometers (MODIS) on the NASA Aqua and Terra platforms, the US Navy microwave WindSat radiometer, the Advanced Very High Resolution Radiometer (AVHRR) on several NOAA satellites, and in situ SST observations from the NOAA iQuam project. The ice concentration data are from the archives at the EUMETSAT Ocean and Sea Ice Satellite Application Facility (OSI SAF) High Latitude Processing Center and are also used for an improved SST parameterization for the high-latitudes.

The dataset also contains additional variables for some granules including a SST anomaly derived from a MUR climatology and the temporal distance to the nearest IR measurement for each pixel.

This dataset is funded by the NASA MEaSUREs program (http://earthdata.nasa.gov/our-community/community-data-system-programs/measures-projects), and created by a team ledby Dr. Toshio M. Chin from JPL. It adheres to the GHRSST Data Processing Specification (GDS) version 2 format specifications. Use the file global metadata "history:" attribute to determine if a granule is near-realtime or retrospective.

1.4 Document Maintenance

This document is generated and maintained by NOAA's National Centers for Environmental Information. More on policy is available at https://www.ncei.noaa.gov/.

2. Results

The data stewardship maturity assessment information is summarized in Table 1. Each component is displayed along with its corresponding score in a color-coded table.

Table 2. Dataset and Data Stewardship Maturity Assessment Metadata	
Dataset Title	GHRSST Level 4 MUR Global Foundation Sea Surface Temperature Analysis (v4.1) (GDS versions 1 and 2)
Dataset Information URL	https://www.ncei.noaa.gov/metadata/geoportal/rest/metadata/item/gov.noaa.nodc%3AGHRSST-MUR-JPL-L4-GLOB/html
Data Provider POC (Name; Email; Affiliation)	National Centers for Environmental Information, NESDIS, NOAA, U.S. Department of Commerce301-713-3277NCEI.Info@noaa.gov
Dataset POC (Name; Email; Affiliation)	Edward ArmstrongNASA/JPL/PODAAC, Physical Oceanography Distributed Active Archive Center, Jet Propulsion Laboratory, NASAedward.m.armstrong@jpl.nasa.gov
SMM Version (Document ID and Version Number)	NCDC-CICS-SMM_0001_Rev.1 12/09/2014
SMM POC (Name; E-mail; Affiliation)	Ge Peng, ge.peng@uah.edu, University of Alabama-Huntsville
SMM Template Version (Document ID and Version Numbers)	NCDC-CICS-SMM_0001_Rev.1 v4.0 06/23/2015
SMM Template POC	Ge Peng, ge.peng@uah.edu, University of Alabama-Huntsville
SMM Assessment Version (v<nn>r<mm>, e.g., v01r00)	v01r00
SMM Assessment Date (MM/DD/YYYY)	02/01/2022
SMM Assessment POC (Name; E-mail; Affiliation)	Katy Luquire, catherine.luquire@noaa.gov, CASE Consultants International
Stewardship Maturity Ratings (each key component) (kc1/kc2/kc3/kc4/kc5/kc6/kc7/kc8/kc9)	5/5/4.5/5/4/4.5/4.3/4/4
SMM Original Assessment Date (MM/DD/YYYY)	02/01/2022
SMM Original Assessment POC (Name; E-mail; Affiliation)	Katy Luquire, catherine.luquire@noaa.gov, CASE Consultants International
SMM Last Modified Date (MM/DD/YYYY)	02/01/2022
SMM Last Modification POC (Name; E-mail; Affiliation)	Katy Luquire, catherine.luquire@noaa.gov, CASE Consultants International
SMM Modified Date (MM/DD/YYYY)	02/01/2022
SMM Modification POC (Name; E-mail; Affiliation)	Katy Luquire, catherine.luquire@noaa.gov, CASE Consultants International

Table 3. Stewardship Maturity Levels and Detailed Justifications for Each of Nine DSMM Key Components for the Dataset.	
DSMM Key Component	Stewardship Maturity Rating, Justification, and Comments
Preservability	Level 5 ▪ Archived by NCEI, which is NOAA designated repository. NOAA is compliant to NARA standards ▪ Metadata following ISO 19115-2 standards. ▪ Compliant to OAIS RM ▪ Plans to update metadata to ISO 19115-1 at a later date ▪ Using NCEI Silver Spring Archive Management System, AMS. Comments:
Accessibility	Level 5 ▪ Collection level searchable online ▪ Granule level is searchable online ▪ Additional search options available from collection level site ▪ Direct file download available from ▪ THREDDS: https://www.ncei.noaa.gov/thredds-ocean/catalog/ghrsst/L4/GLOB/JPL/MUR/catalog.html ▪ HTTP: https://www.ncei.noaa.gov/data/oceans/ghrsst/L4/GLOB/JPL/MUR/ ▪ FTP: ftp://ftp-oceans.ncei.noaa.gov/pub/data.nodc/ghrsst/L4/GLOB/JPL/MUR/ ▪ These data are in NetCDF format following ACDD and/or CF conventions. ▪ Dissemination reports are available to the public https://www.ncei.noaa.gov/access/ghrsst-long-term-stewardship-and-reanalysis-facility/ ▪ Future technology changes are planned Comments:

Table 3. Stewardship Maturity Levels and Detailed Justifications for Each of Nine DSMM Key Components for the Dataset.	
DSMM Key Component	Stewardship Maturity Rating, Justification, and Comments
Usability	Level 4.5 ▪ The format is interoperable: nc.bz2 for granules ▪ User Guide [GHRSST, 2011] GHRSST User Guide version 9.1, 2011, retrieved online: https://www.nodc.noaa.gov/archive/arc0072/0123222/1.1/data/0-data/GHRSSTUserGuidev91.pdf (Accessed 24 January 2022) is available online https://www.nodc.noaa.gov/archive/arc0072/0123222/1.1/data/0-data/GHRSSTUserGuidev91.pdf ▪ GDS 2.0 User Manual [GHRSST GDS 2.0, 2012] is available online https://www.nodc.noaa.gov/archive/arc0072/0123222/1.1/data/0-data/GDS20r5.pdf ▪ Algorithm/ATBD documents [Chin, 2013] is available online https://doi.org/10.1016/j.rse.2017.07.029 ▪ Error estimates described in Algorithm document Enhanced online capability available through multiple data servers maintained at NCEI: LAS, THREDDS, OPeNDAP ▪ This collection includes data from the following product(s): GHRSST Level 4 MUR Global Foundation Sea Surface Temperature Analysis (v4.1) (GHRSST-MUR-JPL-L4-GLOB-v4.1); GHRSST Level 4 MUR Global Foundation Sea Surface Temperature Analysis (GHRSST-JPL-L4UHfnd-GLOB-MUR). ▪ Dataset citation landing page from PODAAC site: ▪ GHRSST Level 4 MUR Global Foundation Sea Surface Temperature Analysis: https://doi.org/10.5067/GHGMR-4FJ01 ▪ GHRSST Level 4 MUR Global Foundation Sea Surface Temperature Analysis (v4.1): https://doi.org/10.5067/GHGMR-4FJ04 ▪ No external ranking Comments:
Production Sustainability	Level 5 ▪ The dataset is currently supported, according to LTSRF Table: https://www.ncei.noaa.gov/access/ghrsst-long-term-stewardship-and-reanalysis-facility/ ▪ Long-term institutional commitment JPL, NASA Jet Propulsion Laboratory, USA ▪ Long-term international commitment (GHRSST is an international group) ▪ Changes for technology are available from individual dataset producers. Comments: Changes for technology are available from individual dataset producers. NOAA does not have them documented. From LTSRF page, the product is listed under JPL MUR GLOB
Data Quality Assurance	Level 4 ▪ Data Quality Assurance procedure is defined, documented and implemented in Algorithm document: [Chin, 2013] is available online https://doi.org/10.1016/j.rse.2017.07.029 ▪ File level quality flags exist which can be considered limited data quality assurance metadata. Comments:

Table 3. Stewardship Maturity Levels and Detailed Justifications for Each of Nine DSMM Key Components for the Dataset.	
DSMM Key Component	Stewardship Maturity Rating, Justification, and Comments
Data Quality Control/ Monitoring	Level 4.5 ▪ Limited Quality Control metrics are available: http://www.star.nesdis.noaa.gov/sod/sst/squam/L4/index.html# ▪ Sampling and analysis are frequent and systematic, but not automatic ▪ Procedure documented and available online ▪ Community metrics defined and partially implemented ▪ Anomaly detection and documented in GDS 2.0 User Manual [GHRSST GDS, 2012] is available online https://www.nodc.noaa.gov/archive/arc0072/0123222/1.1/data/0-data/GDS20r5.pdf ▪ Cross-validation documented in ATBD [Chin, 2013] is available online https://doi.org/10.1016/j.rse.2017.07.029 ▪ Conforming to community quality metadata & standards Comments:
Data Quality Assessment	Level 4.3 ▪ Research product assessed in the publication: [Chin, 1998] is available online http://doi.org/10.1175/1520-0426(1998)015%3c0741:BSHWSS%3e2.0.CO;2 ▪ Operational product documented in ATBD [Chin, 2013] is available online https://doi.org/10.1016/j.rse.2017.07.029 ▪ File level quality flags exist which can be considered limited data quality assurance metadata. ▪ Conforming to community quality metadata & standards Comments:
Transparency / Traceability	Level 4 ▪ Product information available in literature: [Chin, 1998] is available online http://doi.org/10.1175/1520-0426(1998)015%3c0741:BSHWSS%3e2.0.CO;2 ▪ Algorithm/ATBD document: [Chin, 2013] is available online https://doi.org/10.1016/j.rse.2017.07.029 ▪ Data citation tracked from the PODAAC landing page: ▪ GHRSST Level 4 MUR Global Foundation Sea Surface Temperature Analysis: DOI: 10.5067/GHGMR-4FJ01 ▪ GHRSST Level 4 MUR Global Foundation Sea Surface Temperature Analysis (v4.1): DOI: 10.5067/GHGMR-4FJ04 ▪ OID assigned: gov.noaa.nodc:GHRSST-MUR-JPL-L4-GLOB ▪ GHRSST datasets are under Configuration Management principles: https://doi.org/10.5281/zenodo.4700465 Comments:

Table 3. Stewardship Maturity Levels and Detailed Justifications for Each of Nine DSMM Key Components for the Dataset.	
DSMM Key Component	Stewardship Maturity Rating, Justification, and Comments
Data Integrity	Level 4 ▪ Data archive integrity verifiable - Checksum technology is available, each GHRSST_L4_MUR_GFSSTA package is accompanied by a manifest in XML format containing hash digests generated using various algorithms, including MD5, SHA-1, SHA-384, etc. That includes checksums (.md5) for every file package. https://www.nodc.noaa.gov/archive/arc0037/0078758/0078758.1.1.xml ▪ Data authenticity is verifiable (since data can be downloaded via HTTPS and HTTPS uses certificates to prove site authenticity) ▪ NCEI-MD does not provide digital signatures for data dissemination Comments:

3. Acknowledgment

This work is supported by the NOAA OneStop Project.

We thank the dataset POCs for their valuable input, as well as the collaborative efforts of the OneStop teams, especially the Metadata team. We would also like to show appreciation to Ge Peng for her contributions.

The draft of this data stewardship maturity report is systematically generated by a tool created by Kieran Hodnett and populated with the stewardship maturity assessment done by the author(s) of this report. The tool was developed based on a Word template created collaboratively by Robert Partee II, Raisa Ionin, Paul Lemieux III, Ge Peng, Don Collins, and Sonny Zinn with helpful input from the NOAA Central Library and the NCEI Communication Team.

4. References

Casey, K. (2016), The NOAA OneStop data discover and access framework project, Version:June 3, 2016. https://cdn.ioos.noaa.gov/media/2017/12/OneStop-IOOS-DMAC-03-June-2016.pdf

Peng, G. (2015) The scientific data stewardship maturity assessment model template, Version: NCDC-CICS-SMM-0001-Rev.1 v4.0 6/23/2015. doi:10.6084/m9.figshare.1211954.

Peng, G., J.L. Privette, E.J. Kearns, N.A. Ritchey, and S. Ansari (2015), A unified framework for measuring stewardship practices applied to digital environmental datasets, *Data Science Journal*, 13, 231-253, doi: 10.2481/dsj.14-049.

Peng, G., J. Lawrimore, V. Toner, C. Lief , R. Baldwin, N. Ritchey, D. Brinegar, and S. A. Delgreco (2016) assessing stewardship naturity of the global historical climatology network-monthly (GHCN-M) dataset: use case study and lessons learned, D-Lib Magazine, 22, doi:10.1045/november2016-peng.

The Recommended GHRSST Data Specification (GDS) GDS 2.0 revision 5, 2012, retrieved online https://www.nodc.noaa.gov/archive/arc0072/0123222/1.1/data/0-data/GDS20r5.pdf (Accessed 24 January 2022)

Chin, M., J. Vazquez, and E. Armstrong (2017), A multi-scale, high-resolution analysis of global sea surface temperature, _Remote Sensing of Environment_ 200 (2017): 154-169, retrieved online: https://doi.org/10.1016/j.rse.2017.07.029 (Accessed 31 January 2022)

Chin, M., J. Vazquez, and E. Armstrong (2017), A multi-scale, high-resolution analysis of global sea surface temperature, _Remote Sensing of Environment_ 200 (2017): 154-169, doi: 10.1016/j.rse.2017.07.029 (Accessed 31 January 2022)

The Recommended GHRSST Data Specification (GDS) GDS 2.0 revision 5, 2012, retrieved online https://www.nodc.noaa.gov/archive/arc0072/0123222/1.1/data/0-data/GDS20r5.pdf (Accessed 31 January 2022)

Chin, M., J. Vazquez, and E. Armstrong (2017), A multi-scale, high-resolution analysis of global sea surface temperature, _Remote Sensing of Environment_ 200 (2017): 154-169, doi: 10.1016/j.rse.2017.07.029 (Accessed 31 January 2022)

Chin, M., J. Vazquez, and E. Armstrong (2017), A multi-scale, high-resolution analysis of global sea surface temperature, _Remote Sensing of Environment_ 200 (2017): 154-169, doi: 10.1016/j.rse.2017.07.029 (Accessed 31 January 2022)

Appendix I: The Scientific Data Stewardship Maturity Matrix (DSMM)

Table A1: This matrix (Version: NCDC-CICS-SMM-0001-Rev.1. 12/09/2014) describes the criterion used to evaluate data stewardship maturity for each of the nine DSMM key components [*Peng et al.*, 2015].

DSMM Component	**Level 1** ***Ad hoc*** Little or no management	**Level 2** ***Minimal*** Limited management	**Level 3** ***Intermediate*** Defined management, partially implemented	**Level 4** ***Advanced*** Well-defined management, fully implemented	**Level 5** ***Optimal*** Full management, audited, measured, controlled
Preservability *(The state of being preservable)*	Any storage location Data only	Non-designated repository Redundancy Limited archiving metadata	Designated archive Redundancy Community-standard archiving metadata Conforming to limited archiving standards	Level 3 + Conforming to community archiving standards	Level 4 + Archiving process performance controlled, measured, and audited Future archiving standard changes planned
Accessibility *(The state of being searchable and accessible publicly)*	Not publically available person-to-person	Publically available direct file download (e.g., via anonymous FTP server) Collection or dataset level searchable online	Level 2 + Non-standard data service Limited data server performance Granule/file level searchable Limited search metrics	Level 3 + Community-standard data service Enhanced data server performance Conforming to community search metrics Dissemination report metrics defined and implemented internally	Level 4 + Dissemination reports available online Future technology and standard changes planned

Usability *(The state of being easy to use)*	Extensive product-specific knowledge required No documentation online	Non-standard data format Limited documentation (e.g., user's guide online)	Community standard-based interoperable format & metadata Documentation (e.g. source code, product algorithm document, processing or/and data flow diagram) online	Level 3 + Basic capability (e.g., subsetting, aggregating) & data characterization overall/global, e.g., climatology, error estimates) available online	Level 4 + Enhanced online capability (e.g., visualization, multiple data formats) Community metrics of data characterization (regional/cell) online External ranking
Production Sustainability *(The state of data production being sustainable and extendable)*	Ad Hoc or Not applicable To obligation or deliverable requirement	Short-term Individual PI's commitment (grant obligations)	Medium-term Institutional commitment (contractual deliverables with specs and schedule defined)	Long-term Institutional commitment Product improvement process in place	Level 4 + National or international commitment Changes for echnology planned
Data Quality Assurance *(The state of data quality being assured)*	Data quality assurance (DQA) procedure unknown or none	Ad Hoc and random QA procedure not defined and documented	DQA procedure defined and documented and partially implemented	DQA procedure well documented, fully implemented and available online with master reference data Limited data quality assurance metadata	Level 4 + DQA procedure monitored and reported Conforming to community quality metadata & standards External review

Data Quality Control/ Monitoring *The state of data quality being controlled and monitored*	None or Sampling unknown or spotty Analysis unknown or random in time	Sampling and analysis are regular in time and space Limited product-specific metrics defined & implemented	Level 2 + Sampling and analysis are frequent and systematic but not automatic Community metrics defined and partially implemented Procedure documented and available online	Level 3 + Anomaly detection procedure well-documented and fully implemented using community metrics, automatic, tracked and reported Limited quality monitoring metadata	Level 4 + Cross-validation of temporal & spatial characteristics Physical consistency check Conforming to community quality metadata & standards
Data Quality Assessment *(The state of data quality being assessed)*	Algorithm/ method/model Theoretical basis assessed (methods and results online)	Level 1 + Research product assessed (methods and results online)	Level 2 + Operational product assessed (methods and results online)	Level 3 + Quality metadata assessed Limited quality assessment metadata	Level 4 + Assessment performed on a recurring basis Conforming to community quality metadata & standards External ranking
Transparency/ Traceability *(The state of being transparent, trackable, and traceable)*	Limited product information available Person-to-person	Product information available in literature	Algorithm Theoretical Basis Document (ATBD) & source code online Dataset configuration managed (CM) Unique Object Identifier (OID) assigned (dataset, documentation, source code) Data citation tracked (e.g., utilizing Digital Object Identifier	Level 3 + Operational Algorithm Description (OAD) online, OID assigned, and under CM	Level 4 + System information online Complete data provenance online

Data Integrity *(The state of data integrity being verifiable)*	Unknown or no data ingest integrity check	Data ingest integrity verifiable (e.g, checksum technology)	(DOI) system) Level 2 + Data archive integrity verifiable	Level 3 + Data access integrity verifiable Conforming to community data integrity technology standard	Level 4 + Data authenticity verifiable (e.g., data signature technology) Performance of data integrity check monitored and reported