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Data Stewardship Maturity Report for GHRSST Level 2P Western Pacific Regional Skin Sea Surface Temperature from the Multifunctional Transport Satellite 2 (MTSAT-2) (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 - 3.5	Data Quality Control/Monitoring - 3.5
Data Quality Assessment - 3	Transparency/Traceability - 3	Data Integrity - 3

NOAA National Centers for Environmental Information January 2020

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 2P Western Pacific Regional Skin Sea Surface Temperature from the Multifunctional Transport Satellite 2 (MTSAT-2) (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 2P Western Pacific Regional Skin Sea Surface Temperature from the Multifunctional Transport Satellite 2 (MTSAT-2) (GDS versions 1 and 2), is assessed based on a reference stewardship maturity framework. The current maturity ratings of GHRSST Level 2P Western Pacific Regional Skin Sea Surface Temperature from the Multifunctional Transport Satellite 2 (MTSAT-2) (GDS versions 1 and 2) are at Level 1 or higher for all nine key components with zero Level 1, zero Level 2, five Level 3, one 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 2P Western Pacific Regional Skin Sea Surface Temperature from the Multifunctional Transport Satellite 2 (MTSAT-2) (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.

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Data Stewardship Maturity Report for GHRSST Level 2P Western Pacific Regional Skin Sea Surface Temperature from the Multifunctional Transport Satellite 2 (MTSAT-2) (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

Multi-functional Transport Satellites (MTSAT) are a series of geostationary weather satellites operated by the Japan Meteorological Agency (JMA). MTSAT carries an aeronautical mission to assist air navigation, plus a meteorological mission to provide imagery over the Asia-Pacific region for the hemisphere centered on 140 East. The meteorological mission includes an imager giving nominal hourly full Earth disk images in five spectral bands (one visible, four infrared). MTSAT are spin stabilized satellites. With this system images are built up by scanning with a mirror that is tilted in small successive steps from the north pole to south pole at a rate such that on each rotation of the satellite an adjacent strip of the Earth is scanned. It takes about 25 minutes to scan the full Earth's disk. This builds a picture 10,000 pixels for the visible images (1.25 km resolution) and 2,500 pixels (4 km resolution) for the infrared images. The MTSAT-2 (also known as Himawari 7) and its radiometer (MTSAT-2 Imager) was successfully launched on 18 February 2006.

For this Group for High Resolution Sea Surface Temperature (GHRSST) dataset, skin sea surface temperature (SST) measurements are calculated from the IR channels of the MTSAT-2 Imager full resolution data in satellite projection on a hourly basis by using Bayesian Cloud Mask algorithm at the Office of Satellite and Product Operations (OSPO). L2P datasets including Single Sensor Error Statistics (SSES) are then derived following the GHRSST Data Processing Specification (GDS) version 2.0.

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 2P Western Pacific Regional Skin Sea Surface Temperature from the Multifunctional Transport Satellite 2 (MTSAT-2) (GDS versions 1 and 2)
Dataset Information URL	https://www.ncei.noaa.gov/access/metadata/landing-page/bin/iso?id=gov.noaa.nodc:GHRSST-MTSAT2-OSPO-L2P
Data Provider POC (Name; Email; Affiliation)	National Centers for Environmental Information, NESDIS, NOAA, U.S. Department of Commerce301-713-3277 NCEI. Info@noaa.gov
Dataset POC (Name; Email; Affiliation)	Robert Potash; OSDPD; NOAA Office of Satellite Data Processing and Distribution; 301-763-8384bob.potash@noaa.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)	v01r07
SMM Assessment Date (MM/DD/YYYY)	04/18/2019
SMM Assessment POC (Name; E-mail; Affiliation)	Raisa Ionin, raisa.ionin@noaa.gov, Earth Resources Technology, Inc.
Stewardship Maturity Ratings (each key component) (kc1/kc2/kc3/kc4/kc5/kc6/kc7/kc8/kc9)	5/5/4.5/5/3.5/3.5/3/3/3
SMM Original Assessment Date (MM/DD/YYYY)	08/15/2016
SMM Original Assessment POC (Name; E-mail; Affiliation)	Raisa Ionin, raisa.ionin@noaa.gov, Earth Resources Technology, Inc.
SMM Last Modified Date (MM/DD/YYYY)	11/17/2021
SMM Last Modification POC (Name; E-mail; Affiliation)	Lori Hager, lori.hager@noaa.gov , CASE Consultants International
SMM Modified Date (MM/DD/YYYY)	04/18/2019
SMM Modification POC (Name; E-mail; Affiliation)	Raisa Ionin, raisa.ionin@noaa.gov, Earth Resources Technology, Inc.

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 OIAS 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/L2P/MTSAT2/OSPO/catalog.html ▪ HTTP: https://www.ncei.noaa.gov/data/oceans/ghrsst/L2P/MTSAT2/OSPO/ ▪ FTP: ftp://ftp-oceans.ncei.noaa.gov/pub/data.nodc/ghrsst/L2P/MTSAT2/OSPO/ ▪ 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: NetCDF or nc.gz for granules ▪ User Guide [GHRSST, 2011] is available online https://www.nodc.noaa.gov/archive/arc0072/0123222/1.1/data/0-data/GHRSSTUserGuidev91.pdf ▪ User Manual [GHRSST, 2011] is available online https://www.nodc.noaa.gov/archive/arc0072/0123222/1.1/data/0-data/GDS20r5.pdf ▪ All GHRSST collections have error estimate. ▪ All GHRSST collections have enhanced online capability (e.g., visualization, multiple data formats): TDS, DAP (*data servers maintained at NCEI); access from metadata main landing page ▪ A GHRSST User Guide, Quick Start Guide, GHRSST Data Specification (GDS) manual, and other relevant documents describing GHRSST data sets can be found in the archive accession, Documentation for The Group for High Resolution Sea Surface Temperature (GHRSST) data archived at NODC (NODC Accession 0123222), http://data.nodc.noaa.gov/cgi-bin/iso?id=gov.noaa.nodc:0123222 ▪ Algorithm documentation is available: ▪ [Maturi, 2008] is available online http://doi.org/10.1175/2008BAMS2528.1 ▪ GOES Sea Surface Temperature Products: Background, SOCD - GOES SST Products - Background. Available from: https://www.star.nesdis.noaa.gov/GOESCal/index.php (Accessed 25 February 2021) ▪ [Maturi, E.] Retrieved from https://ams.confex.com/ams/pdfpapers/79202.pdf ▪ 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 ▪ Long-term institutional commitment through The Officeof Satellite and Product Operations (OSPO),NOAA, 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 OSPO, then MTSAT2

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 Assurance	Level 3.5 ▪ Data quality assurance procedure is defined, documented and implemented based on the publications: ▪ [Maturi, 2008] is available online http://doi.org/10.1175/2008BAMS2528.1 ▪ GOES Sea Surface Temperature Products: Background, SOCD - GOES SST Products - Background. Available from: https://www.star.nesdis.noaa.gov/GOESCal/index.php (Accessed 25 February 2021) ▪ [Maturi, E.] Retrieved from https://ams.confex.com/ams/pdfpapers/79202.pdf ▪ File level quality flags exist which can be considered limited data quality assurance metadata. Comments:
Data Quality Control/ Monitoring	Level 3.5 ▪ Quality Control metrics are available: ▪ Sampling and analysis are frequent, and systematic, and automatic ▪ Procedure documented and available online ▪ Community metrics defined and partially implemented ▪ Comments:
Data Quality Assessment	Level 3 ▪ Algorithm document is available ▪ Research product assessed ▪ Operational product assessed ▪ All based on the publications: ▪ [Maturi, 2008] is available online http://doi.org/10.1175/2008BAMS2528.1 ▪ GOES Sea Surface Temperature Products: Background, SOCD - GOES SST Products - Background. Available from: (Accessed 25 February 2021) ▪ [Maturi, E.] Retrieved from https://ams.confex.com/ams/pdfpapers/79202.pdf 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
Transparency / Traceability	Level 3 ▪ Limited product information available, metadata only on GHRSST_L2P_WPRSST_MTSAT-2 landing page: https://www.ncei.noaa.gov/access/metadata/landing-page/bin/iso?id=gov.noaa.nodc:GHRSST-MTSAT2-OSPO-L2P ▪ Product information available in literature: ▪ [Maturi, 2008] is available online http://doi.org/10.1175/2008BAMS2528.1 ▪ GOES Sea Surface Temperature Products: Background, SOCD - GOES SST Products - Background. Available from: (Accessed 25 February 2021) ▪ [Maturi, E.] Retrieved from https://ams.confex.com/ams/pdfpapers/79202.pdf ▪ Algorithm available in the following publications: ▪ [Maturi, 2008] is available online http://doi.org/10.1175/2008BAMS2528.1 ▪ GOES Sea Surface Temperature Products: Background, SOCD - GOES SST Products - Background. Available from: (Accessed 25 February 2021) ▪ [Maturi, E.] Retrieved from https://ams.confex.com/ams/pdfpapers/79202.pdf ▪ GHRSST datasets are under Configuration Management principles: ftp://ftp.nodc.noaa.gov/nodc/archive/arc0072/0123222/2.2/data/0-data/governance-documents/ ▪ OID assigned at the NCEI landing page: 10.7289/V5DF6P8F ▪ DOI assigned from NOAA PODAAC site: MTSAT2-OSPO-L2P-v1.0 Comments:
Data Integrity	Level 3 ▪ Checksum technology Data archive integrity verifiable - Checksum technology is available, each GHRSST_L2P_WPRSST_MTSAT_2package 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/arc0060/0111376/0111376.1.1.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: Example of a checksum file (.md5 file) also can be seen at ftp://podaac-ftp.jpl.nasa.gov/allData/ghrsst/data/GDS2/L2P/MTSAT2/OSPO/v1/2015/007/PODAAC ftp site: ftp://podaac-ftp.jpl.nasa.gov/allData/ghrsst/data/GDS2/L2P/MTSAT2/OSPO/v1

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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.

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 December 22, 2016)

The Recommended GHRSST Data Specification (GDS) GDS 2.0 revision 5, 2011, retrieved online https://www.nodc.noaa.gov/archive/arc0072/0123222/1.1/data/0-data/GDS20r5.pdf (Accessed 22 December 2016)

Maturi, E., A. Harris, J. Mittaz, C. Merchant, B. Potash, W. Meng, and J. Sapper (2008), NOAA's Sea Surface Temperature Products From Operational Geostationary Satellites, _Bulletin of the American Meteorological Society_, 89(12), 1877–1888, doi:10.1175/2008bams2528.1

Maturi, E., A. Harris, J. Mittaz, C. Merchant, B. Potash, W. Meng, and J. Sapper (2008), NOAA's Sea Surface Temperature Products From Operational Geostationary Satellites, _Bulletin of the American Meteorological Society_, 89(12), 1877–1888, doi:10.1175/2008bams2528.1

Geostationary Sea Surface Temperature Product Validation and Methodology

Maturi, E., A. Harris, J. Mittaz, C. Merchant, B. Potash, W. Meng, and J. Sapper (2008), NOAA's Sea Surface Temperature Products From Operational Geostationary Satellites, _Bulletin of the American Meteorological Society_, 89(12), 1877–1888, doi:10.1175/2008bams2528.1

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