IOOS
Integrated Ocean Observing System

Manual for
Real-Time Oceanographic Data Quality Control Flags

Version 1.1
May 2017

Document Validation

U.S. IOOS Program Office Validation

May 19, 2017

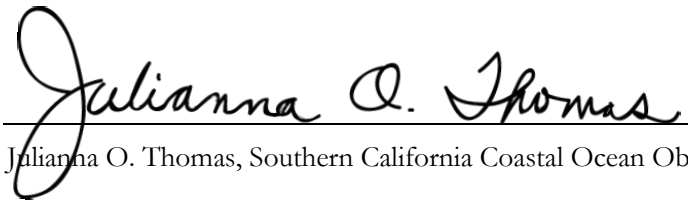
Carl C. Gouldman, U.S. IOOS Program Director — Date

QARTOD Project Manager Validation

May 19, 2017

Kathleen Bailey, U.S. IOOS Project Manager — Date

QARTOD Board of Advisors Validation



May 19, 2017

Julianna O. Thomas, Southern California Coastal Ocean Observing System — Date

Table of Contents

List of Tables

Revision History

Date	Revision Description	Notes
January 2014	Original Document Published	
May 2017	Revise cover page to include new IOOS and QARTOD logo. Revise dates on *Document Validation* page and substitute new IOOS logo (page ii). Add statement requesting feedback from *Manual Users* (page v). Update *Acknowledgements* to include version 1.1 team members (page vi). Update *Acronyms and Abbreviations* (page vii). Update definitions of real time and operator, add interoperable, quality assurance, and quality control, alphabetize, and revise sentence structure in *Terms and Definitions* (page viii). Revise *Acceptance of Standards and Need for Flag Translators* to reflect updated and additional manuals that have been developed (page 1). Revise *Identification and Selection of an Existing Standard* (page 2). Revise content in *Definition of the Accepted Standard*, adding paragraph and table with data flags and descriptions; adjusted table numbering accordingly (page 2). Update content in *Advanced Flagging Schemes* (page 3). Added section on *Implementation* (page 4) Update content in *Applications of Flags* (page 6). Update link to code repository in *Summary* (page 7). Update Useful Links (page 9) Update Version 1.1 Data Flags Manual Team members (pages A-1 through A-5). Add appendix B: example of implementation code. (pages B-1 through B-19	

Endorsement Disclaimer

Mention of a commercial company or product does not constitute an endorsement by NOAA. Use of information from this publication for publicity or advertising purposes concerning proprietary products or the tests of such products is not authorized.

Request to Manual Users

To gauge the success of the QARTOD project, it helps to be aware of groups working to utilize these QC tests. Please notify us of your efforts or intentions to implement QARTOD processes by sending a brief email to data.ioos@noaa.gov **or posting a notice at** http://www.linkedin.com/groups?gid=2521409**.**

Acknowledgements

Thanks to all who assisted in the preparation of this document by providing content and reviewing drafts. Special thanks to the Data Management and Communications (DMAC) community members, especially Emilio Mayorga (NANOOS/University of Washington) for his significant support and contribution to this manual update, as well as his thoughtful insights about flag implementation. We are also grateful to: Scripps Institution of Oceanography's Coastal Data Information Program team for providing their data flagging example, Luke Campbell (RPS Group) for sharing the CDL code as an example of data flag implementation, and Doug Wilson and others at the NOAA Chesapeake Bay Office for supporting that implementation effort.

Appendix A contains the names and affiliations of all those who contributed to the original document and were invited to review updated versions of this data QC flag manual.

Acronyms and Abbreviations

AOOS	Alaska Ocean Observing System
CariCOOS	Caribbean Coastal Ocean Observing System
CDIP	Coastal Data Information Program
CDL	Common Data Language
CeNCOOS	Central and Northern California Ocean Observing System
CF	netCDF Climate and Forecast (CF) Metadata Conventions
CO-OPS	Center for Operational Oceanographic Products and Services
CORMS	Continuous Operational Real-Time Monitoring System
DCP	Data Collection Platform
DMAC	Data Management and Communications
GCOOS	Gulf of Mexico Coastal Ocean Observing System
GLOS	Great Lakes Observing System
GOOS	Global Ocean Observing System
IOC	Intergovernmental Oceanographic Commission
IOOS	Integrated Ocean Observing System
MARACOOS	Mid-Atlantic Regional Association Coastal Ocean Observing System
MBARI	Monterey Bay Aquarium Research Institute
NANOOS	Northwest Association of Networked Ocean Observing Systems
NCDDC	National Coastal Data Development Center
NDBC	National Data Buoy Center
NERACOOS	Northeastern Regional Association of Coastal Ocean Observing Systems
netCDF	Network Common Data Form
NOAA	National Oceanic and Atmospheric Administration
NODC	National Oceanographic Data Center
NOS	National Ocean Service
PacIOOS	Pacific Islands Ocean Observing System
QARTOD	Quality-Assurance/Quality Control of Real-Time Oceanographic Data
QA	Quality Assurance
QC	Quality Control
RA	Regional Association
RCOOS	Regional Coastal Ocean Observing System
SCCOOS	Southern California Coastal Ocean Observing System
SECOORA	Southeast Coastal Ocean Observing Regional Association
SIO	Scripps Institution of Oceanography
UNESCO	United Nations Environmental, Scientific, and Cultural Organization
USACE	U.S. Army Corps of Engineers
WHOI	Woods Hole Oceanographic Institution

Document Purpose

The U.S. Integrated Ocean Observing System (IOOS®) has issued Quality Assurance/Quality Control of Real-Time Oceanographic Data (QARTOD) manuals to be used for identifying the quality of oceanographic data in real time. This data QC flag manual provides information to operators of ocean observing systems about the purpose and protocols of marking or flagging data, so that subsequent use of the data can be properly controlled by both users and automated processes.

Please reference this document as:

> U.S. Integrated Ocean Observing System, 2017. Manual for the Use of Real-Time Oceanographic Data Quality Control Flags, Version 1.1. 43 pp.

Terms and Definitions

This manual contains several terms whose meanings are critical to those using the manual. These terms are included in the following table to ensure that the meanings are clearly defined.

Data Quality Flag	Data quality flag is metadata associated with a specific data point indicating the results of one or more QC tests.
Data Record	A data record is one or more messages that form a coherent, logical, and complete observation.
Data User	A data user is a middle or endpoint entity desiring information, but not necessarily knowledgeable in methods used to obtain the information.
Interoperable	Interoperable means the ability of two or more systems to exchange and mutually use data, metadata, information, or system parameters using established protocols or standards.
Operator	Operators are individuals or entities who are responsible for collecting and providing data.
Quality Assurance	QA involves processes that are employed with hardware to support the generation of high quality data.
Quality Control	QC involves follow-on steps that support the delivery of high quality data and requires both automation and human intervention.
Real Time	Real time means that: data are delivered without delay for immediate use; time series extends only backwards in time, where the next data points are not available; and sample intervals may range from a few seconds to a few hours or even days, depending upon the sensor configuration.
Summary Flag	Summary flag is a single flag set to the worst case of all QC flags within the data record.

Background

Need for Flags

Real-time oceanographic data are employed for a wide variety of applications and users. Some applications/users may require that only data of the highest quality be used, and others may seek an indication that a data point is questionable. Some users may prefer the delivery of all data, to be quality controlled using their own criteria. Successful use of the data will depend upon the knowledge, skills, and diligence of the user. Erroneous use of bad data or questionable/good data identified as bad can have serious consequences. For example, specific data points collected during a sudden increase in wind speed resulting from a localized summer thunderstorm may be outside expected wind speeds. However, the automated deletion of such data results in a loss of vital information concerning the weather event.

Operators of observing systems may be best suited to determine the quality of their observations and to document their findings by generating metadata to accompany the observations. Information generated by software in real time about the data quality is referred to as data quality flags, which become an embedded part of the output data stream. As such, the first value added by generating data quality flags is that the quality of the data has been considered at all—sometimes data flow without any evaluation of their quality.

Multiple Standards

The Intergovernmental Oceanographic Commission/United Nations Environmental, Scientific, and Cultural Organization (IOC/UNESCO) issued a document (hereafter referred to as IOC 54:V3) (UNESCO 2013) with seven examples of flag schemes. Other flag scheme examples exist, including those from the European Global Ocean Observing Systems DATA-MEQ Working Group (Pouliquen et al. 2011) and the National Oceanic and Atmospheric Administration (NOAA) National Ocean Service (NOS) Center for Operational Oceanographic Products and Services (CO-OPS) (Evans et al. 2003). Some flag schemes may simply assign a good or bad rating, which is sufficient for operators/users who desire only good data. At the other extreme, flag schemes can generate a detailed indication of why a data point has been flagged, which is helpful to those responsible for troubleshooting and repairing a sensor.

Acceptance of Standards and Need for Flag Translators

The U.S. IOOS QARTOD Project must accommodate a wide variety of operator QC capabilities. Most operators do not collect sufficient data to justify accepting only the best data and discarding lower quality data—all data can have value to some users. Some operators have highly evolved QC processes in place, and they are not inclined to replace those processes. Other operators may set a few rudimentary min/max thresholds to eliminate outlier data, which, without a flagging scheme, could be interpreted as a data gap. Operators may also have limited resources to implement additional processes/flags.

Diversity in flag schemes is no different than that found worldwide in language, currency, engineering units, etc. One overarching standard may evolve over time, but meanwhile, a near-term solution is to create metadata translation tables to convert one standard to another. Both IOC 54:V3 and Schlitzer 2013 provide good examples of such translations.

QARTOD Data Flag Protocol

Identification and Selection of an Existing Standard

IOC 54:V3 was issued in 2013, shortly after the first QARTOD QC manual was published. A review of the various existing flag standards indicated that the standard suggested in early QARTOD manuals nearly matched the "Primary Level" scheme presented in IOC 54:V3. Rather than adhere to two nearly identical standards, QARTOD decided to adopt the IOC 54:V3 scheme and modify one existing QARTOD manual (dissolved oxygen, accomplished in April 2015) to conform to IOC 54:V3.

Definition of the Accepted Standard

The IOC 54:V3 Primary Level flagging standard (UNESCO 2013) is shown in table 1.

Table 1. Primary Level Flagging Standard.

Value	Primary-Level Flag Short Name	Definition
1	Good	Passed documented required QC tests
2	Not evaluated, not available or unknown	Used for data when no QC test performed or the information on quality is not available
3	Questionable/suspect	Failed non-critical documented metric or subjective test(s)
4	Bad	Failed critical documented QC test(s) or as assigned by the data provider
9	Missing data	Used as place holder when data are missing

QARTOD discourages use of the *Flag 2 Not Evaluated* flag, as this violates the very first of the *Seven QARTOD Data Management Laws*, which is that "every real-time observation distributed to the ocean community must be accompanied by a quality descriptor" (NOAA 2009).

Further, QARTOD slightly expands the definition of the Flag 3 value to be "Suspect or Of High Interest" to emphasize the importance of retaining the human element within the QC process for such values. The full QARTOD flagging definitions table is given in table 2.

Table 2. QARTOD flagging definitions based on UNESCO 2013.

Flag	Description
Pass=1	Data have passed critical real-time quality control tests and are deemed adequate for use as preliminary data.
Not evaluated=2	Data have not been QC-tested, or the information on quality is not available.
Suspect or Of High Interest=3	Data are considered to be either suspect or of high interest to data providers and users. They are flagged suspect to draw further attention to them by operators.
Fail=4	Data are considered to have failed one or more critical real-time QC checks. If they are disseminated at all, it should be readily apparent that they are not of acceptable quality.
Missing data=9	Data are missing; used as a placeholder.

Advanced Flagging Schemes

In IOC 54:V3, a two-tiered flag scheme is proposed, but only the Level 1 tier is described. Likewise, the U.S. IOOS QARTOD Project adopts only the Level 1 flags but encourages the use of Level 2 flags for additional documentation that may be of use to operators and data users. Level 2 flags may be closely related to a specific sensor and consequently more challenging to translate to another standard. Several examples of such flags are taken from IOC 54:V3 and expanded in table 3.

Table 3. Example of quality control tests and data processing history (IOC 54:V3).

Globally impossible value (exceeds low or high thresholds)
Monthly climatology standard deviation test (exceeds warning or failure thresholds)
Excessive spike check (exceeds warning or failure, low or high thresholds)
Excessive offset/bias when compared to a reference data set (exceeds warning or failure, low or high thresholds)
Unexpected X/Y ratio (e.g., chemical stoichiometry or property-property X to T, S, density, among others)
Excessive spatial gradient or pattern check ("bullseyes")
Below detection limit of method

Summary Flags

Operators may generate summary flags for the convenience of data users. A summary flag is set to the highest-level (worst case) flag found in the detailed tests outlined in QARTOD data quality manuals, such as U.S. IOOS 2015. For example, if any tests generate a *Flag 4 Bad* flag, then the summary flag is set to *4 Bad*. This provides a simple check that users can invoke when they require only a basic level of QC. QARTOD does not require use of the summary flag.

Implementation

QARTOD does not dictate the methods operators use to implement data QC flags. Individual bits representing the five identified flag values (tables 1 and 2) may be set, making data masking an easy task. More likely, operators will identify a character string that can detect more than the five values found in tables 1 and 2. Operators are encouraged to provide code that can be used to read data and metadata, including these QC flags.

IOOS intends to use existing community standards to the maximum extent possible (e.g., QARTOD, Climate and Forecast [CF], Attribute Conventions for Data Discovery [ACDD]). IOOS-specific interpretations of vague elements of community standards, or IOOS-specific extensions to community standards, will be posted at https://ioos.github.io/ioos-netcdf/ as they are developed.

One example of a flag implementation approach for netCDF files that leverages some CF conventions is shown in appendix B. The CDL code was developed for the Chesapeake Bay Interpretive Buoy System, with input, feedback, and engagement from the IOOS DMAC community. It includes QARTOD testing and flagging for location, conductivity and salinity, dissolved oxygen, turbidity, water temperature, and chlorophyll data. The following example shows a portion of that CDL code, demonstrating implementation of the sea water salinity primary QC flag:

```
float sea_water_salinity(time) ;
sea_water_salinity:_FillValue = -9999.f ;
sea_water_salinity:units = "psu" ;
sea_water_salinity:standard_name = "sea_water_salinity" ;
sea_water_salinity:long_name = "Sea Water Salinity" ;
sea_water_salinity:comment = "The unit of salinity is PSU, which is dimensionless. The units attribute
should be given as 1e-3 or 0.001 i.e. parts per thousand if salinity is in PSU." ;
sea_water_salinity:coordinates = "time latitude longitude depth" ;
sea_water_salinity:source = "Observational data from a buoy" ;
sea_water_salinity:platform = "platform" ;
sea_water_salinity:cell_methods = "time: point depth: point" ;
sea_water_salinity:valid_min = 0.07f ;
sea_water_salinity:valid_max = 0.09f ;
sea_water_salinity:ancillary_variables = "sea_water_salinity_flatline_qc sea_water_salinity_range_qc
sea_water_salinity_gradient_qc sea_water_salinity_spike_qc sea_water_salinity_qc" ;
byte sea_water_salinity_qc(time) ;
sea_water_salinity_qc:_FillValue = 9b ;
sea_water_salinity_qc:standard_name = "sea_water_salinity status_flag" ;
sea_water_salinity_qc:long_name = "Sea Water Salinity Primary QC" ;
sea_water_salinity_qc:flag_values = 1b, 2b, 3b, 4b, 9b ;
sea_water_salinity_qc:flag_meanings = "GOOD NOT_EVALUATED SUSPECT BAD MISSING" ;
sea_water_salinity_qc:comment = "Primary QC flag" ;
sea_water_salinity_qc:coordinates = "time latitude longitude depth" ;
sea_water_salinity_qc:source = "Observational data from a buoy" ;
sea_water_salinity_qc:platform = "platform" ;
```

In this example, it was decided to represent data flags as ASCII characters rather than encoded bits because such representation is clear, self-describing, easily expandable, and eases the programming burden. The drawback is that the flag values increase the data file size more than bit encoding. Additional documentation of CF conventions can be found at http://cfconventions.org/Data/cf-conventions/cf-conventions-1.6/build/cf-conventions.html#idp5025120.

The following example uses a salinity/temperature/pressure record with values of 3.55 (practical salinity unit), 15.3 °C (temperature), and 15.12 decibars (pressure)[1]. The three (**3**) in the last part of the record indicates there were no failures or warnings and would read as:

3550 1530 1512 00000000000000000000000000000000 **3**00

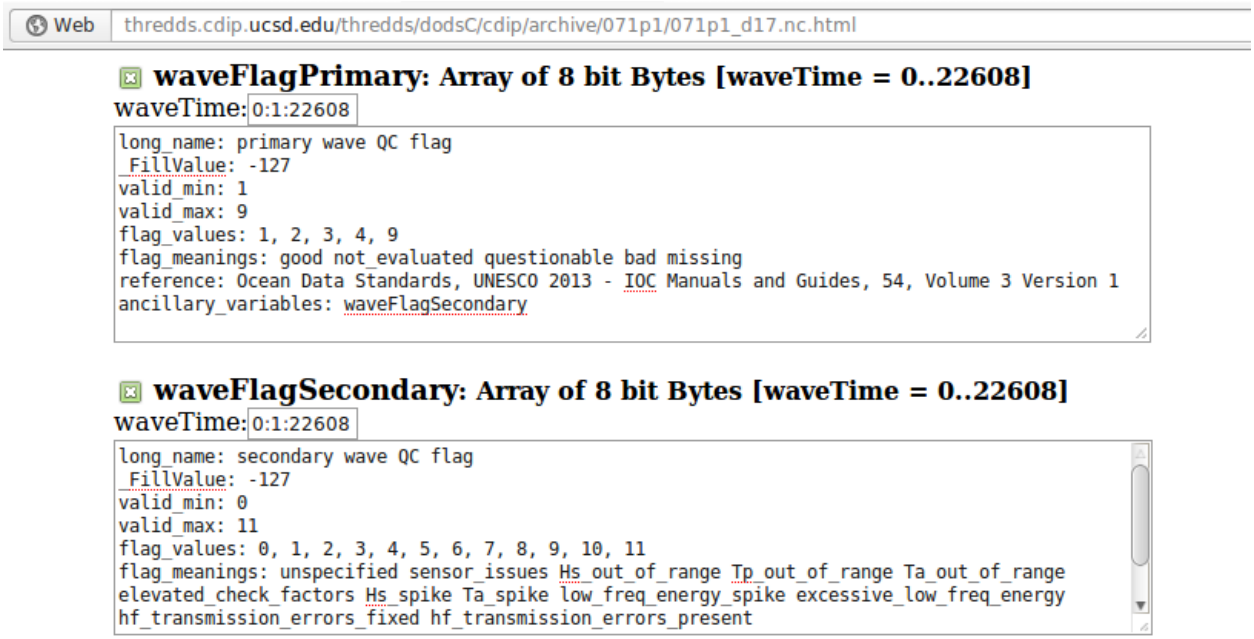
Each bit is labeled as to its importance.

	Info	This is merely information; it does not reflect directly on the quality of the data.
	Warning	This is a warning; the data quality may be affected.
	Failure	The data has failed a real-time QA check; use at your own risk.
Bit 0	Failure	Salinity out of range
Bit 1	Failure	Salinity zero
Bit 2	Failure	Water temperature out of range
Bit 3	Failure	Time is > 6 minutes off
Bit 4	Warning	Salinity is flat
Bit 5	Warning	Water temperature is flat
Bit 6	Failure	No data
Bit 7	Failure	Barometric pressure is out of range
Bit 8	Warning	Barometric pressure is flat
Bit 9	Failure	Water temperature sensor disabled by CORMS[2]
Bit 10	Failure	Conductivity (salinity) sensor disabled by CORMS

An advanced character string flagging scheme can be found in a Scripps Institution of Oceanography (SIO) Coastal Data Information Program (CDIP) Thematic Real-Time Environmental Distributed Data Services (THREDDS) server that hosts the CDIP netCDF data sets (http://thredds.cdip.ucsd.edu/thredds/catalog.html). Table 4 shows the two-tier IOC flagging used by CDIP: waveFlagPrimary holds the IOC-recommended primary level values, and waveFlagSecondary holds additional information as assigned by CDIP QC routines, based on both the data type and sensor type (a Datawell directional Waverider).

[1] For a more complete explanation, see http://www.tidesandcurrents.noaa.gov/publications/pufff4.pdf).
[2] The Continuous Operational Real-Time Monitoring System serves as the primary automated QC system for NOAA/NOS/CO-OPS oceanographic and meteorological data.

Table 4. Example shows a two-tier flagging scheme (courtesy of the SIO CDIP team).



The formatting and use of flags and other metadata, either through automated interoperability methods or human use, continue to evolve (see http://www.jcommops.org/dbcp/data/metadata.html). Further information and training about metadata standards can be found at https://www.ncddc.noaa.gov/metadata-standards/metadata-training/course-one/.

Application of Flags

QC flags provide important information to those who may use the data to make important decisions in real time. The data and the metadata (including QC flag settings) provided in real time should be archived exactly as they were delivered to users. Therefore, data records containing QC flags set in real time should retain those flags permanently. Operators should have a high degree of confidence in the assigned QC flags. Post-processed records may yield a different finding, but these records should not overwrite the real-time records.

However, there are limited instances where it is acceptable to change a real-time flag. In some cases, QC tests operate on a data point that may be one or more cycles old. For example, a spike check might use data points at N_{-2} and N_0 to examine data point N_{-1}. In this case, the flag for the QC test on the data point N_0 should be set to "*2 Not evaluated, not available, or unknown.*" After receipt of the subsequent data point, N_0 becomes N_{-1}, the spike test can be applied, and the flag can be changed as necessary. Operators and users must understand that some tests operate over several data points, and the determination of summary flags must also take this into consideration. The situation highlights the importance of users (both machine-to-machine and end users) evaluating the QC flags for several time-steps backward.

Summary

There are a wide variety of applications for and users of real-time oceanographic data. The quality of those data is dependent upon many factors, including the ability to apply QC flags to real-time data streams. This QC flag manual has been compiled considering multiple QC flagging schemes that have been documented by various sources. The flagging standard suggested in early QARTOD manuals nearly matched the "Primary Level" scheme presented in IOC 54:V3. Therefore, QARTOD has accepted the IOC 54:V3 scheme as its data QC flag protocol.

Although content for this manual is drawn from many sources, it is primarily intended to support the existing QARTOD QC manuals—not to address all data flagging schemes. Guidance provided in this manual, like that in other QARTOD manuals, also considers that operators have different skill levels and resources with which to apply QC flags. Some operators already employ advanced flagging schemes, while others use basic thresholds to flag outlier data.

Operators implementing QARTOD QC tests maintain a code repository (https://github.com/ioos/qartod) where others may find or post examples of code in use. Such leveraging of developed code is strongly encouraged and appreciated.

Each QC manual is envisioned as a dynamic document and will be posted on the QARTOD website at https://ioos.noaa.gov/project/qartod/. This process allows for QC manual updates as technology development occurs for both upgrades of existing sensors and new sensors.

References

Evans, M., French, G., and Bethem, T., 2003. Information Systems Branch PORTS Uniform Flat File Format (PUFFF) NOAA/NOS/CO-OPS, Silver Spring, Maryland. 32 pp. http://tidesandcurrents.noaa.gov/publications/pufff4.pdf

NOAA, 2009. Fifth Workshop on the QA/QC of Real-Time Oceanographic Data. November 16-19, 2009. 136 pp. Omni Hotel, Atlanta, Georgia. http://nautilus.baruch.sc.edu/twiki/pub/Main/WebHome/QARTOD_final_09.pdf.

Paris. Intergovernmental Oceanographic Commission of UNESCO, 2013. Ocean Data Standards, Vol.3: Recommendation for a Quality Flag Scheme for the Exchange of Oceanographic and Marine Meteorological Data. (IOC Manuals and Guides, 54, Vol. 3.) 12 pp. (English.)(IOC/2013/MG/54-3) http://www.nodc.noaa.gov/oceanacidification/support/MG54_3.pdf

Pouliquen, S., 2011. Recommendations for in-situ data Real Time Quality Control. 23 pp. http://eurogoos.eu/download/publications/rtqc.pdf

Schlitzer, R., 2013. Ocean Quality Flag Schemes and Mapping between Them, Version 1.4. Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany. 18 pp. http://odv.awi.de/fileadmin/user_upload/odv/misc/ODV4_QualityFlagSets.pdf

U.S. Integrated Ocean Observing System, 2015. Manual for Real-Time Quality Control of In-Situ Surface Wave Data Version 2.0: A Guide to Quality Control and Quality Assurance of In-Situ Surface Wave Observations. 64 pp. https://ioos.noaa.gov/ioos-in-action/wave-data/

Useful Links

U.S. IOOS Website
https://ioos.noaa.gov/project/qartod/

Ocean Data Standards Pilot Project
http://www.oceandatastandards.org/

Hydrographic Data Formats
https://geo.h2o.ucsd.edu/documentation/manuals/pdf/90_1/chap4.pdf

CF Conventions and Metadata
http://cfconventions.org/

Data Buoy Cooperation Panel Meta-T Pilot Project
https://marinemetadata.org/community/teams/metat/introduction

NCEI Metadata Training
https://www.ncddc.noaa.gov/metadata-standards/metadata-training/course-one/

Introduction to Oceanographic Data Management
http://classroom.oceanteacher.org/course/view.php?id=131

Argo Flag Scheme
http://www.usgodae.org/argo/argo-dm-user-manual.pdf

Appendix A. QARTOD Data QC Flag Manual Team

QARTOD Data QC Flag Manual Reviewers, Version 1.1

Name	Organization
Mark Bushnell	U.S. IOOS
Luke Campbell	RPS Group
Emilio Mayorga	NANOOS/University of Washington

U.S. IOOS Regional Associations, Version 1.1

Name	Organization
Josie Quintrell	IOOS Association
Clarissa Anderson	SCCOOS
Francisco Chavez	CeNCOOS
Debra Hernandez	SECOORA
Barbara Kirkpatrick	GCOOS
Gerhard Kuska	MARACOOS
Molly McCammon	AOOS
Julio Morell	CariCOOS
Ru Morrison	NERACOOS
Jan Newton	NANOOS
Melissa Iwamoto	PacIOOS
Kelli Paige	GLOS

QARTOD Board of Advisors, Version 1.1

Name	Organization
Kathleen Bailey – Project Manager	U.S. IOOS
Julie Bosch	NOAA/National Centers for Environmental Information
Eugene Burger	NOAA/Pacific Marine Environmental Laboratory
Janet Fredericks	Woods Hole Oceanographic Institution
Matt Howard	GCOOS/Texas A&M University
Bob Jensen	U.S. Army Corps of Engineers
Chris Paternostro	NOS/CO-OPS
Mario Tamburri	University of Maryland Center for Environmental Science / Chesapeake Biological Laboratory
Julie Thomas – BOA Chair	SCCOOS/Scripps Institution of Oceanography/Coastal Data Information Program

DMAC Community, Version 1.1

Regional Associations

AOOS	**GCOOS**
Carol Janzen	Bob Currier
CARICOOS	**SECOORA**
Miguel Canals	Abbey Wakely
Roy Watlington	Debra Hernandez
	Filipe Pires Alvarenga Fernandes

Research Organizations

Gulf of Maine Research Institute	**Scripps Institution of Oceanography**
Eric Bridger	Darren Wright
Monterey Bay Aquarium Research Institute	**Smithsonian Environmental Research Center**
Aric Bickel	Matthew Ogburn
Anderson David	
Fred Bahr	

Federal and State Agencies

Bureau of Ocean Energy Management	**Environmental Protection Agency**
Brian Zelenke	Dwane Young
Jonathan Blythe	
Great Lakes Commission	
Guan Wang	
National Oceanic and Atmospheric Administration	
Becky Baltes	Jennifer Bosch
Bill Woodward	Jennifer Patterson
Kenneth Casey	Jessica Morgan
Mark VanWaes	Kevin O'Brien
Alexander Birger	Lynn Dewitt
Bob Simons	Mark Bushnell
Byron Kilbourne	Mathew Biddle
Dave Easter	Micah Wengren
Derrick Snowden	Rita Adak
Eric Johnson	Robert Bassett
Frank Lodato	Samantha Simmons
Gabrielle Canonico	Thomas Ryan
Jack Harlan	Tiffany Vance
Jason Gedamke	Tim Boyer
Jeff de La Beaujardiere	Tony Lavoi
Jenifer Rhoades	Xiaoyan Li
U.S. Army Corps of Engineers	**U.S. Geological Survey**
Jeff Lillycrop	Abigail Benson
	James Kreft
	Rich Signell
	Sky Bristol

Academic Institutions	
University of Maine	Bob Fleming
University of Maryland	Mario Tamburri
Dalhousie University	Brad Covey Lenore Bajona Richard Davis
University of Puerto Rico	Jorge Capella Juan Orlando Gonzalez Lopez Julio Morell
University of Hawaii	Chris Ostrander James T. Potemra Melissa Iwamoto
University of Washington	Emilio Mayorga
Texas A & M University	Felimon Gayanilo
Rutgers University	John Kerfoot Michael Vardaro
University of Tasmania	Peter Walsh
Private Industry	
LimnoTech	Kathy Koch Tad Slawecki
RPS Group	Kelly Knee Luke Campbell Melanie Gearon
Axiom	Kyle Wilcox Rob Bochenek Shane StClair
Animal Tracking Network	Jonathan Pye

Data QC Flag Manual Editors, Version 1.0

Name	Organization
Mark Bushnell, Lead	CoastalObsTechServices LLC/CO-OPS
Ray Toll	Old Dominion University/NDBC
Helen Worthington	REMSA/CO-OPS

Data QC Flag Manual Reviewers/DMAC Committee, Version 1.0

Name	Organization
Rob Bochenek	AOOS/Axiom Consulting & Design
Julie Bosch	NOAA/NCDDC
Eric Bridger	NERACOOS/GMRI
Jorge Capella	CariCOOS/University of Puerto Rico
Jeremy Cothran	SECOORA
Janet Fredericks	WHOI
Lisa Hazard	SCCOOS/Scripps Institute of Oceanography
Bob Heitsenrether	NOAA/CO-OPS
Matt Howard	GCOOS/Texas A&M University
Steven Le	CeNCOOS/SAIC
Emilio Mayorga	NANOOS/University of Washington
Jennifer Patterson	CeNCOOS/MBARI
Jim Potemra	PacIOOS/University of Hawaii
Rob Ragsdale	U.S. IOOS
Tad Slawecki	GLOS/LimnoTech
Derrick Snowden	U.S. IOOS
Shane StClair	AOOS/Axiom Consulting & Design
Vembu Subramanian	SECOORA
Julie Thomas	SIO/CDIP
Kyle Wilcox	MARACOOS/Applied Science Associates, Inc.

QARTOD Board of Advisors, Version 1.0

Name	Organization
Joe Swaykos - Chair	NDBC
Derrick Snowden	U.S. IOOS
Julie Bosch	NOAA/NCDDC
Julie Thomas	SIO/CDIP
Derrick Snowden	US IOOS
Matt Howard	GCOOS
Chris Paternostro	NOAA/CO-OPS
Bob Jensen	USACE
Janet Fredericks	WHOI

U.S. IOOS Regional Associations, Version 1.0	
Name	**Organization**
Josie Quintrell – Director	U.S. IOOS Association
Leslie Rosenfeld	CeNCOOS
Jan Newton	NANOOS
Debra Hernandez	SECOORA
Julie Thomas	SCCOOS
Ann Jochens	GCOOS
Gerhard Kuska	MARACOOS
Molly McCammon	AOOS
Ru Morrison	NERACOOS
Jorge Corridor	CariCOOS
Heather Kerkering	PacIOOS
Jen Read	GLOS

Appendix B. Implementation Example for netCDF Flags

```
netcdf cbibs-WaterQuality_44041_2016-02-05 {
dimensions:
        time = 140 ;
variables:
        byte crs ;
                crs:grid_mapping_name = "latitude_longitude" ;
                crs:epsg_code = "EPSG:4326" ;
                crs:semi_major_axis = 6378137.f ;
                crs:inverse_flattening = 298.2572f ;
        byte platform ;
                platform:wmo_code = "44041" ;
                platform:long_name = "Jamestown CBIBS Buoy" ;
                platform:abbreviation = "J" ;
                platform:references = "http://www.buoybay.org/site/public/data/status.php" ;
                platform:cf_role = "timeseries_id" ;
        double time(time) ;
                time:units = "seconds since 1970-01-01 00:00:00 UTC" ;
                time:calendar = "gregorian" ;
                time:axis = "T" ;
                time:standard_name = "time" ;
                time:long_name = "Time" ;
        float latitude ;
                latitude:standard_name = "latitude" ;
                latitude:long_name = "Nominal latitude" ;
                latitude:units = "degrees_north" ;
                latitude:axis = "Y" ;
                latitude:comment = "Nominal latitude of station.  Does not account for drift over
time, see `measured_lat` for this" ;
                latitude:valid_min = 37.2042 ;
                latitude:valid_max = 37.2042 ;
        float longitude ;
                longitude:standard_name = "longitude" ;
                longitude:long_name = "Nominal longitude" ;
                longitude:units = "degrees_east" ;
                longitude:axis = "X" ;
                longitude:comment = "Nominal longitude of station.  Does not account for drift
over time, see `measured_lat` for this" ;
                longitude:valid_min = -76.7773 ;
                longitude:valid_max = -76.7773 ;
        float depth ;
                depth:long_name = "depth" ;
                depth:standard_name = "depth" ;
                depth:axis = "Z" ;
                depth:units = "meters" ;
                depth:positive = "up" ;
                depth:valid_min = 0.f ;
                depth:valid_max = 0.f ;
        float measured_lon(time) ;
```

measured_lon:standard_name = "longitude" ;
measured_lon:long_name = "Measured longitude" ;
measured_lon:units = "degrees_east" ;
measured_lon:comment = "Measured longitude of buoy" ;
measured_lon:ancillary_variables = "location_test" ;
float measured_lat(time) ;
measured_lat:standard_name = "latitude" ;
measured_lat:long_name = "Measured latitude" ;
measured_lat:units = "degrees_north" ;
measured_lat:comment = "Measured latitude of buoy" ;
measured_lat:ancillary_variables = "location_test" ;
float location_test(time) ;
location_test:long_name = "Location Test" ;
location_test:flag_values = 1b, 2b, 3b, 4b, 9b ;
location_test:flag_meanings = "GOOD NOT_EVALUATED SUSPECT BAD MISSING" ;
location_test:comment = "Test checks that the reported present physical location (latitude/longitude) is within operator - determined limits. The location test(s) can v ary from: 1) a simple invalid location, to 2) a more complex check for displacement (DISP) exceeding a distance limit RANGEMAX based upon a previous location and platform speed.Operators may also check for 3) erroneous locations based upon other criteria, such as reported positions over land, as appropriate." ;
location_test:references = "http://www.ioos.noaa.gov/qartod/welcome.html" ;
float seanettle_probability(time) ;
seanettle_probability:_FillValue = -9999.f ;
seanettle_probability:units = "percent" ;
seanettle_probability:long_name = "Seanettle Probability" ;
seanettle_probability:comment = "Percent chance of encountering Sea Nettles" ;
seanettle_probability:coordinates = "time latitude longitude depth" ;
seanettle_probability:source = "Observational data from a buoy" ;
seanettle_probability:platform = "platform" ;
seanettle_probability:cell_methods = "time: point depth: point" ;
seanettle_probability:valid_min = 0.0001246126f ;
seanettle_probability:valid_max = 0.000180543f ;
seanettle_probability:ancillary_variables = "seanettle_probability_range_qc seanettle_probability_qc" ;
byte seanettle_probability_qc(time) ;
seanettle_probability_qc:_FillValue = 9b ;
seanettle_probability_qc:long_name = "Seanettle Probability Primary QC" ;
seanettle_probability_qc:flag_values = 1b, 2b, 3b, 4b, 9b ;
seanettle_probability_qc:flag_meanings = "GOOD NOT_EVALUATED SUSPECT BAD MISSING" ;
seanettle_probability_qc:comment = "Primary QC flag" ;
seanettle_probability_qc:coordinates = "time latitude longitude depth" ;
seanettle_probability_qc:source = "Observational data from a buoy" ;
seanettle_probability_qc:platform = "platform" ;
byte seanettle_probability_range_qc(time) ;
seanettle_probability_range_qc:_FillValue = 9b ;
seanettle_probability_range_qc:long_name = "Seanettle Probability Gross Range Test" ;
seanettle_probability_range_qc:flag_values = 1b, 2b, 3b, 4b, 9b ;

seanettle_probability_range_qc:flag_meanings = "GOOD NOT_EVALUATED SUSPECT BAD MISSING" ;
seanettle_probability_range_qc:comment = "All sensors have a limited output range, and this can form the most rudimentary gross range check. No values less than a minimum value or greater tha n the maximum value the sensor can output (SENSOR_MIN, SENSOR_MAX) are acceptable. Additionally, the operator can select a smaller span (USER_MIN, USER_MAX) based upon local knowledge or a desire to draw attention to extreme values. NOTE: Operators may choose to flag as suspect values that exceed the calibration span but not the hardware limits (e.g., a value that sensor is not capable of producing)." ;
seanettle_probability_range_qc:references = "http://www.ioos.noaa.gov/qartod/welcome.html" ;
float sea_water_salinity(time) ;
sea_water_salinity:_FillValue = -9999.f ;
sea_water_salinity:units = "psu" ;
sea_water_salinity:standard_name = "sea_water_salinity" ;
sea_water_salinity:long_name = "Sea Water Salinity" ;
sea_water_salinity:comment = "The unit of salinity is PSU, which is dimensionless. The units attribute should be given as 1e-3 or 0.001 i.e. parts per thousand if salinity is in PSU." ;
sea_water_salinity:coordinates = "time latitude longitude depth" ;
sea_water_salinity:source = "Observational data from a buoy" ;
sea_water_salinity:platform = "platform" ;
sea_water_salinity:cell_methods = "time: point depth: point" ;
sea_water_salinity:valid_min = 0.07f ;
sea_water_salinity:valid_max = 0.09f ;
sea_water_salinity:ancillary_variables = "sea_water_salinity_flatline_qc sea_water_salinity_range_qc sea_water_salinity_gradient_qc sea_water_salinity_spike_qc sea_water_salinity_qc" ;
byte sea_water_salinity_qc(time) ;
sea_water_salinity_qc:_FillValue = 9b ;
sea_water_salinity_qc:standard_name = "sea_water_salinity status_flag" ;
sea_water_salinity_qc:long_name = "Sea Water Salinity Primary QC" ;
sea_water_salinity_qc:flag_values = 1b, 2b, 3b, 4b, 9b ;
sea_water_salinity_qc:flag_meanings = "GOOD NOT_EVALUATED SUSPECT BAD MISSING" ;
sea_water_salinity_qc:comment = "Primary QC flag" ;
sea_water_salinity_qc:coordinates = "time latitude longitude depth" ;
sea_water_salinity_qc:source = "Observational data from a buoy" ;
sea_water_salinity_qc:platform = "platform" ;
byte sea_water_salinity_flatline_qc(time) ;
sea_water_salinity_flatline_qc:_FillValue = 9b ;
sea_water_salinity_flatline_qc:long_name = "Sea Water Salinity Flat Line Test" ;
sea_water_salinity_flatline_qc:standard_name = "sea_water_salinity status_flag" ;
sea_water_salinity_flatline_qc:flag_values = 1b, 2b, 3b, 4b, 9b ;
sea_water_salinity_flatline_qc:flag_meanings = "GOOD NOT_EVALUATED SUSPECT BAD MISSING" ;
sea_water_salinity_flatline_qc:comment = "When some sensors and/or data collection platforms fail, the result can be a continuously repeated observation of the same value. This test compares the present observation n to a number (REP_CNT_FAIL or REP_CNT_SUSPECT) of previous observations. Observation n is flagged if it has the same

value as previous observations within a tolerance value, EPS, to allow for numerical round-off error. Note that historical flags are not changed." ;
sea_water_salinity_flatline_qc:references = "http://www.ioos.noaa.gov/qartod/welcome.html" ;
byte sea_water_salinity_range_qc(time) ;
sea_water_salinity_range_qc:_FillValue = 9b ;
sea_water_salinity_range_qc:long_name = "Sea Water Salinity Gross Range Test" ;
sea_water_salinity_range_qc:standard_name = "sea_water_salinity status_flag" ;
sea_water_salinity_range_qc:flag_values = 1b, 2b, 3b, 4b, 9b ;
sea_water_salinity_range_qc:flag_meanings = "GOOD NOT_EVALUATED SUSPECT BAD MISSING" ;
sea_water_salinity_range_qc:comment = "All sensors have a limited output range, and this can form the most rudimentary gross range check. No values less than a minimum value or greater tha n the maximum value the sensor can output (SENSOR_MIN, SENSOR_MAX) are acceptable. Additionally, the operator can select a smaller span (USER_MIN, USER_MAX) based upon local knowledge or a desire to draw attention to extreme values. NOTE: Operators may choose to flag as suspect values that exceed the calibration span but not the hardware limits (e.g., a value that sensor is not capable of producing)." ;
sea_water_salinity_range_qc:references = "http://www.ioos.noaa.gov/qartod/welcome.html" ;
byte sea_water_salinity_gradient_qc(time) ;
sea_water_salinity_gradient_qc:_FillValue = 9b ;
sea_water_salinity_gradient_qc:long_name = "Sea Water Salinity Rate of Change Test" ;
sea_water_salinity_gradient_qc:standard_name = "sea_water_salinity status_flag" ;
sea_water_salinity_gradient_qc:flag_values = 1b, 2b, 3b, 4b, 9b ;
sea_water_salinity_gradient_qc:flag_meanings = "GOOD NOT_EVALUATED SUSPECT BAD MISSING" ;
sea_water_salinity_gradient_qc:comment = "This test inspects the time series for a time rate of change that exceeds a threshold value identified by the operator. WL values can change substantially over short periods in some locations, hindering the value of this test. A balance must be found between a threshold set too low, which triggers too many false alarms, and one set too high, making the test ineffective. Test implementation can be challenging. Upon failure, it is unknown which point is bad. Further, upon failing a data point, it remains to be determined how the next iteration can be handled.\nThe following suggest two ways to select the thresholds:\n1) The rate of change between WLn-1 and WLn must be less than three standard deviations (3*SD). The SD of the WL time series is computed over the previous 25-hour period (operator-selected value) to accommodate cyclical diurnal and other tidal fluctuations. The local operator determines both the\nnumber of SDs (N_DEV) and the period over which the SDs are calculated (TIM_DEV).\n 2)\nThe rate of change between WLn-1 and WLn must be less than 0.1 meter +2SD." ;
sea_water_salinity_gradient_qc:references = "http://www.ioos.noaa.gov/qartod/welcome.html" ;
byte sea_water_salinity_spike_qc(time) ;
sea_water_salinity_spike_qc:_FillValue = 9b ;
sea_water_salinity_spike_qc:long_name = "Sea Water Salinity Spike Test" ;
sea_water_salinity_spike_qc:standard_name = "sea_water_salinity status_flag" ;
sea_water_salinity_spike_qc:flag_values = 1b, 2b, 3b, 4b, 9b ;

sea_water_salinity_spike_qc:flag_meanings = "GOOD NOT_EVALUATED SUSPECT BAD MISSING" ;
sea_water_salinity_spike_qc:comment = "This check is for single-value spikes, specifically the value at point n-1. Spikes consisting of more than one data point are difficult to capture, but their onset may be flagged by the rate of change test. The spike test consists of two operator-selected thresholds, THRSHLD_LOW and THRSHLD_HIGH. Adjacent data points (n-2 and n0) are averaged to form a spike reference (SPK_REF). The absolute value of the spike is tested to capture positive and negative spikes. Large spikes are easier to identify as outliers and flag as failures. Smaller spikes may be real and are only flagged suspect. The thresholds may be fixed values or dynamically established (for example, a multiple of the standard deviation over an operator-selected period)." ;
sea_water_salinity_spike_qc:references = "http://www.ioos.noaa.gov/qartod/welcome.html" ;
float dissolved_oxygen(time) ;
dissolved_oxygen:_FillValue = -9999.f ;
dissolved_oxygen:units = "mg L-1" ;
dissolved_oxygen:standard_name = "mass_concentration_of_oxygen_in_sea_water" ;
dissolved_oxygen:long_name = "Dissolved Oxygen" ;
dissolved_oxygen:comment = "Mass concentration means mass per unit volume and is used in the construction mass_concentration_of_X_in_Y, where X is a material constituent of Y." ;
dissolved_oxygen:coordinates = "time latitude longitude depth" ;
dissolved_oxygen:source = "Observational data from a buoy" ;
dissolved_oxygen:platform = "platform" ;
dissolved_oxygen:cell_methods = "time: point depth: point" ;
dissolved_oxygen:valid_min = 11.54f ;
dissolved_oxygen:valid_max = 11.9f ;
dissolved_oxygen:ancillary_variables = "dissolved_oxygen_flatline_qc dissolved_oxygen_range_qc dissolved_oxygen_gradient_qc dissolved_oxygen_spike_qc dissolved_oxygen_qc" ;
byte dissolved_oxygen_qc(time) ;
dissolved_oxygen_qc:_FillValue = 9b ;
dissolved_oxygen_qc:standard_name = "mass_concentration_of_oxygen_in_sea_water status_flag" ;
dissolved_oxygen_qc:long_name = "Dissolved Oxygen Primary QC" ;
dissolved_oxygen_qc:flag_values = 1b, 2b, 3b, 4b, 9b ;
dissolved_oxygen_qc:flag_meanings = "GOOD NOT_EVALUATED SUSPECT BAD MISSING" ;
dissolved_oxygen_qc:comment = "Primary QC flag" ;
dissolved_oxygen_qc:coordinates = "time latitude longitude depth" ;
dissolved_oxygen_qc:source = "Observational data from a buoy" ;
dissolved_oxygen_qc:platform = "platform" ;
byte dissolved_oxygen_flatline_qc(time) ;
dissolved_oxygen_flatline_qc:_FillValue = 9b ;
dissolved_oxygen_flatline_qc:long_name = "Dissolved Oxygen Flat Line Test" ;
dissolved_oxygen_flatline_qc:standard_name = "mass_concentration_of_oxygen_in_sea_water status_flag" ;
dissolved_oxygen_flatline_qc:flag_values = 1b, 2b, 3b, 4b, 9b ;
dissolved_oxygen_flatline_qc:flag_meanings = "GOOD NOT_EVALUATED SUSPECT BAD MISSING" ;

dissolved_oxygen_flatline_qc:comment = "When some sensors and/or data collection platforms fail, the result can be a continuously repeated observation of the same value. This test compares the present observation n to a number (REP_CNT_FAIL or REP_CNT_SUSPECT) of previous observations. Observation n is flagged if it has the same value as previous observations within a tolerance value, EPS, to allow for numerical round-off error. Note that historical flags are not changed." ;
dissolved_oxygen_flatline_qc:references = "http://www.ioos.noaa.gov/qartod/welcome.html" ;
byte dissolved_oxygen_range_qc(time) ;
dissolved_oxygen_range_qc:_FillValue = 9b ;
dissolved_oxygen_range_qc:long_name = "Dissolved Oxygen Gross Range Test" ;
dissolved_oxygen_range_qc:standard_name = "mass_concentration_of_oxygen_in_sea_water status_flag" ;
dissolved_oxygen_range_qc:flag_values = 1b, 2b, 3b, 4b, 9b ;
dissolved_oxygen_range_qc:flag_meanings = "GOOD NOT_EVALUATED SUSPECT BAD MISSING" ;
dissolved_oxygen_range_qc:comment = "All sensors have a limited output range, and this can form the most rudimentary gross range check. No values less than a minimum value or greater tha n the maximum value the sensor can output (SENSOR_MIN, SENSOR_MAX) are acceptable. Additionally, the operator can select a smaller span (USER_MIN, USER_MAX) based upon local knowledge or a desire to draw attention to extreme values. NOTE: Operators may choose to flag as suspect values that exceed the calibration span but not the hardware limits (e.g., a value that sensor is not capable of producing)." ;
dissolved_oxygen_range_qc:references = "http://www.ioos.noaa.gov/qartod/welcome.html" ;
byte dissolved_oxygen_gradient_qc(time) ;
dissolved_oxygen_gradient_qc:_FillValue = 9b ;
dissolved_oxygen_gradient_qc:long_name = "Dissolved Oxygen Rate of Change Test" ;
dissolved_oxygen_gradient_qc:standard_name = "mass_concentration_of_oxygen_in_sea_water status_flag" ;
dissolved_oxygen_gradient_qc:flag_values = 1b, 2b, 3b, 4b, 9b ;
dissolved_oxygen_gradient_qc:flag_meanings = "GOOD NOT_EVALUATED SUSPECT BAD MISSING" ;
dissolved_oxygen_gradient_qc:comment = "This test inspects the time series for a time rate of change that exceeds a threshold value identified by the operator. WL values can change substantially over short periods in some locations, hindering the value of this test. A balance must be found between a threshold set too low, which triggers too many false alarms, and one set too high, making the test ineffective. Test implementation can be challenging. Upon failure, it is unknown which point is bad. Further, upon failing a data point, it remains to be determined how the next iteration can be handled.\nThe following suggest two ways to select the thresholds:\n1) The rate of change between WLn-1 and WLn must be less than three standard deviations (3*SD). The SD of the WL time series is computed over the previous 25-hour period (operator-selected value) to accommodate cyclical diurnal and other tidal fluctuations. The local operator determines both the\nnumber of SDs (N_DEV) and the period over which the SDs are calculated (TIM_DEV).\n 2)\nThe rate of change between WLn-1 and WLn must be less than 0.1 meter +2SD." ;
dissolved_oxygen_gradient_qc:references = "http://www.ioos.noaa.gov/qartod/welcome.html" ;
byte dissolved_oxygen_spike_qc(time) ;

dissolved_oxygen_spike_qc:_FillValue = 9b ;
dissolved_oxygen_spike_qc:long_name = "Dissolved Oxygen Spike Test" ;
dissolved_oxygen_spike_qc:standard_name = "mass_concentration_of_oxygen_in_sea_water status_flag" ;
dissolved_oxygen_spike_qc:flag_values = 1b, 2b, 3b, 4b, 9b ;
dissolved_oxygen_spike_qc:flag_meanings = "GOOD NOT_EVALUATED SUSPECT BAD MISSING" ;
dissolved_oxygen_spike_qc:comment = "This check is for single-value spikes, specifically the value at point n-1. Spikes consisting of more than one data point are difficult to capture, but their onset may be flagged by the rate of change test. The spike test consists of two operator-selected thresholds, THRSHLD_LOW and THRSHLD_HIGH. Adjacent data points (n-2 and n0) are averaged to form a spike reference (SPK_REF). The absolute value of the spike is tested to capture positive and negative spikes. Large spikes are easier to identify as outliers and flag as failures. Smaller spikes may be real and are only flagged suspect. The thresholds may be fixed values or dynamically established (for example, a multiple of the standard deviation over an operator-selected period)." ;
dissolved_oxygen_spike_qc:references = "http://www.ioos.noaa.gov/qartod/welcome.html" ;
float turbidity(time) ;
turbidity:_FillValue = -9999.f ;
turbidity:units = "ntu" ;
turbidity:standard_name = "sea_water_turbidity" ;
turbidity:long_name = "Turbidity" ;
turbidity:comment = "" ;
turbidity:coordinates = "time latitude longitude depth" ;
turbidity:source = "Observational data from a buoy" ;
turbidity:platform = "platform" ;
turbidity:cell_methods = "time: point depth: point" ;
turbidity:valid_min = 19.06f ;
turbidity:valid_max = 32.63f ;
turbidity:ancillary_variables = "turbidity_flatline_qc turbidity_range_qc turbidity_gradient_qc turbidity_spike_qc turbidity_qc" ;
byte turbidity_qc(time) ;
turbidity_qc:_FillValue = 9b ;
turbidity_qc:standard_name = "sea_water_turbidity status_flag" ;
turbidity_qc:long_name = "Turbidity Primary QC" ;
turbidity_qc:flag_values = 1b, 2b, 3b, 4b, 9b ;
turbidity_qc:flag_meanings = "GOOD NOT_EVALUATED SUSPECT BAD MISSING" ;
turbidity_qc:comment = "Primary QC flag" ;
turbidity_qc:coordinates = "time latitude longitude depth" ;
turbidity_qc:source = "Observational data from a buoy" ;
turbidity_qc:platform = "platform" ;
byte turbidity_flatline_qc(time) ;
turbidity_flatline_qc:_FillValue = 9b ;
turbidity_flatline_qc:long_name = "Turbidity Flat Line Test" ;
turbidity_flatline_qc:standard_name = "sea_water_turbidity status_flag" ;
turbidity_flatline_qc:flag_values = 1b, 2b, 3b, 4b, 9b ;
turbidity_flatline_qc:flag_meanings = "GOOD NOT_EVALUATED SUSPECT BAD MISSING" ;

turbidity_flatline_qc:comment = "When some sensors and/or data collection platforms fail, the result can be a continuously repeated observation of the same value. This test compares the present observation n to a number (REP_CNT_FAIL or REP_CNT_SUSPECT) of previous observations. Observation n is flagged if it has the same value as previous observations within a tolerance value, EPS, to allow for numerical round-off error. Note that historical flags are not changed." ;

turbidity_flatline_qc:references = "http://www.ioos.noaa.gov/qartod/welcome.html" ;

byte turbidity_range_qc(time) ;

turbidity_range_qc:_FillValue = 9b ;

turbidity_range_qc:long_name = "Turbidity Gross Range Test" ;

turbidity_range_qc:standard_name = "sea_water_turbidity status_flag" ;

turbidity_range_qc:flag_values = 1b, 2b, 3b, 4b, 9b ;

turbidity_range_qc:flag_meanings = "GOOD NOT_EVALUATED SUSPECT BAD MISSING" ;

turbidity_range_qc:comment = "All sensors have a limited output range, and this can form the most rudimentary gross range check. No values less than a minimum value or greater tha n the maximum value the sensor can output (SENSOR_MIN, SENSOR_MAX) are acceptable. Additionally, the operator can select a smaller span (USER_MIN, USER_MAX) based upon local knowledge or a desire to draw attention to extreme values. NOTE: Operators may choose to flag as suspect values that exceed the calibration span but not the hardware limits (e.g., a value that sensor is not capable of producing)." ;

turbidity_range_qc:references = "http://www.ioos.noaa.gov/qartod/welcome.html" ;

byte turbidity_gradient_qc(time) ;

turbidity_gradient_qc:_FillValue = 9b ;

turbidity_gradient_qc:long_name = "Turbidity Rate of Change Test" ;

turbidity_gradient_qc:standard_name = "sea_water_turbidity status_flag" ;

turbidity_gradient_qc:flag_values = 1b, 2b, 3b, 4b, 9b ;

turbidity_gradient_qc:flag_meanings = "GOOD NOT_EVALUATED SUSPECT BAD MISSING" ;

turbidity_gradient_qc:comment = "This test inspects the time series for a time rate of change that exceeds a threshold value identified by the operator. WL values can change substantially over short periods in some locations, hindering the value of this test. A balance must be found between a threshold set too low, which triggers too many false alarms, and one set too high, making the test ineffective. Test implementation can be challenging. Upon failure, it is unknown which point is bad. Further, upon failing a data point, it remains to be determined how the next iteration can be handled.\nThe following suggest two ways to select the thresholds:\n1) The rate of change between WLn-1 and WLn must be less than three standard deviations (3*SD). The SD of the WL time series is computed over the previous 25-hour period (operator-selected value) to accommodate cyclical diurnal and other tidal fluctuations. The local operator determines both the\nnumber of SDs (N_DEV) and the period over which the SDs are calculated (TIM_DEV).\n 2)\nThe rate of change between WLn-1 and WLn must be less than 0.1 meter +2SD." ;

turbidity_gradient_qc:references = "http://www.ioos.noaa.gov/qartod/welcome.html" ;

byte turbidity_spike_qc(time) ;

turbidity_spike_qc:_FillValue = 9b ;

turbidity_spike_qc:long_name = "Turbidity Spike Test" ;

turbidity_spike_qc:standard_name = "sea_water_turbidity status_flag" ;

turbidity_spike_qc:flag_values = 1b, 2b, 3b, 4b, 9b ;

turbidity_spike_qc:flag_meanings = "GOOD NOT_EVALUATED SUSPECT BAD MISSING" ;
turbidity_spike_qc:comment = "This check is for single-value spikes, specifically the value at point n-1. Spikes consisting of more than one data point are difficult to capture, but their onset may be flagged by the rate of change test. The spike test consists of two operator-selected thresholds, THRSHLD_LOW and THRSHLD_HIGH. Adjacent data points (n-2 and n0) are averaged to form a spike reference (SPK_REF). The absolute value of the spike is tested to capture positive and negative spikes. Large spikes are easier to identify as outliers and flag as failures. Smaller spikes may be real and are only flagged suspect. The thresholds may be fixed values or dynamically established (for example, a multiple of the standard deviation over an operator-selected period)." ;
turbidity_spike_qc:references = "http://www.ioos.noaa.gov/qartod/welcome.html" ;
float sea_water_freezing_point(time) ;
sea_water_freezing_point:_FillValue = -9999.f ;
sea_water_freezing_point:units = "deg_C" ;
sea_water_freezing_point:long_name = "Sea Water Freezing Point" ;
sea_water_freezing_point:comment = "Sea Water Freezing Point" ;
sea_water_freezing_point:coordinates = "time latitude longitude depth" ;
sea_water_freezing_point:source = "Observational data from a buoy" ;
sea_water_freezing_point:platform = "platform" ;
sea_water_freezing_point:cell_methods = "time: point depth: point" ;
sea_water_freezing_point:valid_min = NaN ;
sea_water_freezing_point:valid_max = NaN ;
sea_water_freezing_point:ancillary_variables = "sea_water_freezing_point_qc" ;
byte sea_water_freezing_point_qc(time) ;
sea_water_freezing_point_qc:_FillValue = 9b ;
sea_water_freezing_point_qc:long_name = "Sea Water Freezing Point Primary QC" ;
sea_water_freezing_point_qc:flag_values = 1b, 2b, 3b, 4b, 9b ;
sea_water_freezing_point_qc:flag_meanings = "GOOD NOT_EVALUATED SUSPECT BAD MISSING" ;
sea_water_freezing_point_qc:comment = "Primary QC flag" ;
sea_water_freezing_point_qc:coordinates = "time latitude longitude depth" ;
sea_water_freezing_point_qc:source = "Observational data from a buoy" ;
sea_water_freezing_point_qc:platform = "platform" ;
float water_temperature(time) ;
water_temperature:_FillValue = -9999.f ;
water_temperature:units = "deg_C" ;
water_temperature:standard_name = "sea_water_temperature" ;
water_temperature:long_name = "Water Temperature" ;
water_temperature:comment = "" ;
water_temperature:coordinates = "time latitude longitude depth" ;
water_temperature:source = "Observational data from a buoy" ;
water_temperature:platform = "platform" ;
water_temperature:cell_methods = "time: point depth: point" ;
water_temperature:valid_min = 6.27f ;
water_temperature:valid_max = 7.31f ;
water_temperature:ancillary_variables = "water_temperature_attenuated_qc water_temperature_flatline_qc water_temperature_range_qc water_temperature_gradient_qc water_temperature_spike_qc water_temperature_qc" ;

byte water_temperature_qc(time) ;
water_temperature_qc:_FillValue = 9b ;
water_temperature_qc:standard_name = "sea_water_temperature status_flag" ;
water_temperature_qc:long_name = "Water Temperature Primary QC" ;
water_temperature_qc:flag_values = 1b, 2b, 3b, 4b, 9b ;
water_temperature_qc:flag_meanings = "GOOD NOT_EVALUATED SUSPECT BAD MISSING" ;
water_temperature_qc:comment = "Primary QC flag" ;
water_temperature_qc:coordinates = "time latitude longitude depth" ;
water_temperature_qc:source = "Observational data from a buoy" ;
water_temperature_qc:platform = "platform" ;
byte water_temperature_attenuated_qc(time) ;
water_temperature_attenuated_qc:_FillValue = 9b ;
water_temperature_attenuated_qc:long_name = "Water Temperature Attenuated Signal Test" ;
water_temperature_attenuated_qc:standard_name = "sea_water_temperature status_flag" ;
water_temperature_attenuated_qc:flag_values = 1b, 2b, 3b, 4b, 9b ;
water_temperature_attenuated_qc:flag_meanings = "GOOD NOT_EVALUATED SUSPECT BAD MISSING" ;
water_temperature_attenuated_qc:comment = "A common sensor failure mode can provide a data series that is nearly but not exactly a flat line (e.g., if a well orifice becomes wrapped in debris). This test inspects for an SD value or a range variation (MAX-MIN) value that fails to exceed threshold values (MIN_VAR_WARN, MIN_VAR_FAIL) over a selected time period (TST_TIM)." ;
water_temperature_attenuated_qc:references = "http://www.ioos.noaa.gov/qartod/welcome.html" ;
byte water_temperature_flatline_qc(time) ;
water_temperature_flatline_qc:_FillValue = 9b ;
water_temperature_flatline_qc:long_name = "Water Temperature Flat Line Test" ;
water_temperature_flatline_qc:standard_name = "sea_water_temperature status_flag" ;
water_temperature_flatline_qc:flag_values = 1b, 2b, 3b, 4b, 9b ;
water_temperature_flatline_qc:flag_meanings = "GOOD NOT_EVALUATED SUSPECT BAD MISSING" ;
water_temperature_flatline_qc:comment = "When some sensors and/or data collection platforms fail, the result can be a continuously repeated observation of the same value. This test compares the present observation n to a number (REP_CNT_FAIL or REP_CNT_SUSPECT) of previous observations. Observation n is flagged if it has the same value as previous observations within a tolerance value, EPS, to allow for numerical round-off error. Note that historical flags are not changed." ;
water_temperature_flatline_qc:references = "http://www.ioos.noaa.gov/qartod/welcome.html" ;
byte water_temperature_range_qc(time) ;
water_temperature_range_qc:_FillValue = 9b ;
water_temperature_range_qc:long_name = "Water Temperature Gross Range Test" ;
water_temperature_range_qc:standard_name = "sea_water_temperature status_flag" ;
water_temperature_range_qc:flag_values = 1b, 2b, 3b, 4b, 9b ;

water_temperature_range_qc:flag_meanings = "GOOD NOT_EVALUATED SUSPECT BAD MISSING" ;
water_temperature_range_qc:comment = "All sensors have a limited output range, and this can form the most rudimentary gross range check. No values less than a minimum value or greater tha n the maximum value the sensor can output (SENSOR_MIN, SENSOR_MAX) are acceptable. Additionally, the operator can select a smaller span (USER_MIN, USER_MAX) based upon local knowledge or a desire to draw attention to extreme values. NOTE: Operators may choose to flag as suspect values that exceed the calibration span but not the hardware limits (e.g., a value that sensor is not capable of producing)." ;
water_temperature_range_qc:references = "http://www.ioos.noaa.gov/qartod/welcome.html" ;
byte water_temperature_gradient_qc(time) ;
water_temperature_gradient_qc:_FillValue = 9b ;
water_temperature_gradient_qc:long_name = "Water Temperature Rate of Change Test" ;
water_temperature_gradient_qc:standard_name = "sea_water_temperature status_flag" ;
water_temperature_gradient_qc:flag_values = 1b, 2b, 3b, 4b, 9b ;
water_temperature_gradient_qc:flag_meanings = "GOOD NOT_EVALUATED SUSPECT BAD MISSING" ;
water_temperature_gradient_qc:comment = "This test inspects the time series for a time rate of change that exceeds a threshold value identified by the operator. WL values can change substantially over short periods in some locations, hindering the value of this test. A balance must be found between a threshold set too low, which triggers too many false alarms, and one set too high, making the test ineffective. Test implementation can be challenging. Upon failure, it is unknown which point is bad. Further, upon failing a data point, it remains to be determined how the next iteration can be handled.\nThe following suggest two ways to select the thresholds:\n1) The rate of change between WLn-1 and WLn must be less than three standard deviations (3*SD). The SD of the WL time series is computed over the previous 25-hour period (operator-selected value) to accommodate cyclical diurnal and other tidal fluctuations. The local operator determines both the\nnumber of SDs (N_DEV) and the period over which the SDs are calculated (TIM_DEV).\n 2)\nThe rate of change between WLn-1 and WLn must be less than 0.1 meter +2SD." ;
water_temperature_gradient_qc:references = "http://www.ioos.noaa.gov/qartod/welcome.html" ;
byte water_temperature_spike_qc(time) ;
water_temperature_spike_qc:_FillValue = 9b ;
water_temperature_spike_qc:long_name = "Water Temperature Spike Test" ;
water_temperature_spike_qc:standard_name = "sea_water_temperature status_flag" ;
water_temperature_spike_qc:flag_values = 1b, 2b, 3b, 4b, 9b ;
water_temperature_spike_qc:flag_meanings = "GOOD NOT_EVALUATED SUSPECT BAD MISSING" ;
water_temperature_spike_qc:comment = "This check is for single-value spikes, specifically the value at point n-1. Spikes consisting of more than one data point are difficult to capture, but their onset may be flagged by the rate of change test. The spike test consists of two operator-selected thresholds, THRSHLD_LOW and THRSHLD_HIGH. Adjacent data points (n-2 and n0) are averaged to form a spike reference (SPK_REF). The absolute value of the spike is tested to capture positive and negative spikes. Large spikes are easier to identify as outliers and flag as failures. Smaller spikes may be real and are only flagged suspect. The thresholds may

be fixed values or dynamically established (for example, a multiple of the standard deviation over an operator-selected period)." ;
water_temperature_spike_qc:references = "http://www.ioos.noaa.gov/qartod/welcome.html" ;
float chlorophyll(time) ;
chlorophyll:_FillValue = -9999.f ;
chlorophyll:units = "ug L-1" ;
chlorophyll:standard_name = "mass_concentration_of_chlorophyll_in_sea_water" ;
chlorophyll:long_name = "Chlorophyll" ;
chlorophyll:comment = "alias: chlorophyll_concentration_in_sea_water alias: concentration_of_chlorophyll_in_sea_water" ;
chlorophyll:coordinates = "time latitude longitude depth" ;
chlorophyll:source = "Observational data from a buoy" ;
chlorophyll:platform = "platform" ;
chlorophyll:cell_methods = "time: point depth: point" ;
chlorophyll:valid_min = 2.41f ;
chlorophyll:valid_max = 3.33f ;
chlorophyll:ancillary_variables = "chlorophyll_flatline_qc chlorophyll_range_qc chlorophyll_gradient_qc chlorophyll_spike_qc chlorophyll_qc" ;
byte chlorophyll_qc(time) ;
chlorophyll_qc:_FillValue = 9b ;
chlorophyll_qc:standard_name = "mass_concentration_of_chlorophyll_in_sea_water status_flag" ;
chlorophyll_qc:long_name = "Chlorophyll Primary QC" ;
chlorophyll_qc:flag_values = 1b, 2b, 3b, 4b, 9b ;
chlorophyll_qc:flag_meanings = "GOOD NOT_EVALUATED SUSPECT BAD MISSING" ;
chlorophyll_qc:comment = "Primary QC flag" ;
chlorophyll_qc:coordinates = "time latitude longitude depth" ;
chlorophyll_qc:source = "Observational data from a buoy" ;
chlorophyll_qc:platform = "platform" ;
byte chlorophyll_flatline_qc(time) ;
chlorophyll_flatline_qc:_FillValue = 9b ;
chlorophyll_flatline_qc:long_name = "Chlorophyll Flat Line Test" ;
chlorophyll_flatline_qc:standard_name = "mass_concentration_of_chlorophyll_in_sea_water status_flag" ;
chlorophyll_flatline_qc:flag_values = 1b, 2b, 3b, 4b, 9b ;
chlorophyll_flatline_qc:flag_meanings = "GOOD NOT_EVALUATED SUSPECT BAD MISSING" ;
chlorophyll_flatline_qc:comment = "When some sensors and/or data collection platforms fail, the result can be a continuously repeated observation of the same value. This test compares the present observation n to a number (REP_CNT_FAIL or REP_CNT_SUSPECT) of previous observations. Observation n is flagged if it has the same value as previous observations within a tolerance value, EPS, to allow for numerical round-off error. Note that historical flags are not changed." ;
chlorophyll_flatline_qc:references = "http://www.ioos.noaa.gov/qartod/welcome.html" ;
byte chlorophyll_range_qc(time) ;
chlorophyll_range_qc:_FillValue = 9b ;
chlorophyll_range_qc:long_name = "Chlorophyll Gross Range Test" ;

chlorophyll_range_qc:standard_name = "mass_concentration_of_chlorophyll_in_sea_water status_flag" ;
chlorophyll_range_qc:flag_values = 1b, 2b, 3b, 4b, 9b ;
chlorophyll_range_qc:flag_meanings = "GOOD NOT_EVALUATED SUSPECT BAD MISSING" ;
chlorophyll_range_qc:comment = "All sensors have a limited output range, and this can form the most rudimentary gross range check. No values less than a minimum value or greater tha n the maximum value the sensor can output (SENSOR_MIN, SENSOR_MAX) are acceptable. Additionally, the operator can select a smaller span (USER_MIN, USER_MAX) based upon local knowledge or a desire to draw attention to extreme values. NOTE: Operators may choose to flag as suspect values that exceed the calibration span but not the hardware limits (e.g., a value that sensor is not capable of producing)." ;
chlorophyll_range_qc:references = "http://www.ioos.noaa.gov/qartod/welcome.html" ;
byte chlorophyll_gradient_qc(time) ;
chlorophyll_gradient_qc:_FillValue = 9b ;
chlorophyll_gradient_qc:long_name = "Chlorophyll Rate of Change Test" ;
chlorophyll_gradient_qc:standard_name = "mass_concentration_of_chlorophyll_in_sea_water status_flag" ;
chlorophyll_gradient_qc:flag_values = 1b, 2b, 3b, 4b, 9b ;
chlorophyll_gradient_qc:flag_meanings = "GOOD NOT_EVALUATED SUSPECT BAD MISSING" ;
chlorophyll_gradient_qc:comment = "This test inspects the time series for a time rate of change that exceeds a threshold value identified by the operator. WL values can change substantially over short periods in some locations, hindering the value of this test. A balance must be found between a threshold set too low, which triggers too many false alarms, and one set too high, making the test ineffective. Test implementation can be challenging. Upon failure, it is unknown which point is bad. Further, upon failing a data point, it remains to be determined how the next iteration can be handled.\nThe following suggest two ways to select the thresholds:\n1) The rate of change between WLn-1 and WLn must be less than three standard deviations (3*SD). The SD of the WL time series is computed over the previous 25-hour period (operator-selected value) to accommodate cyclical diurnal and other tidal fluctuations. The local operator determines both the\nnumber of SDs (N_DEV) and the period over which the SDs are calculated (TIM_DEV).\n 2)\nThe rate of change between WLn-1 and WLn must be less than 0.1 meter +2SD." ;
chlorophyll_gradient_qc:references = "http://www.ioos.noaa.gov/qartod/welcome.html" ;
byte chlorophyll_spike_qc(time) ;
chlorophyll_spike_qc:_FillValue = 9b ;
chlorophyll_spike_qc:long_name = "Chlorophyll Spike Test" ;
chlorophyll_spike_qc:standard_name = "mass_concentration_of_chlorophyll_in_sea_water status_flag" ;
chlorophyll_spike_qc:flag_values = 1b, 2b, 3b, 4b, 9b ;
chlorophyll_spike_qc:flag_meanings = "GOOD NOT_EVALUATED SUSPECT BAD MISSING" ;
chlorophyll_spike_qc:comment = "This check is for single-value spikes, specifically the value at point n-1. Spikes consisting of more than one data point are difficult to capture, but their onset may be flagged by the rate of change test. The spike test consists of two operator-selected thresholds, THRSHLD_LOW and THRSHLD_HIGH. Adjacent data points (n-2 and n0) are averaged to form a spike reference (SPK_REF). The absolute value of the spike is tested to capture positive and negative spikes. Large spikes are easier to identify as outliers and

flag as failures. Smaller spikes may be real and are only flagged suspect. The thresholds may be fixed values or dynamically established (for example, a multiple of the standard deviation over an operator-selected period)." ;
chlorophyll_spike_qc:references = "http://www.ioos.noaa.gov/qartod/welcome.html" ;
float conductivity(time) ;
conductivity:_FillValue = -9999.f ;
conductivity:units = "S m-1" ;
conductivity:standard_name = "sea_water_electrical_conductivity" ;
conductivity:long_name = "Conductivity" ;
conductivity:comment = "" ;
conductivity:coordinates = "time latitude longitude depth" ;
conductivity:source = "Observational data from a buoy" ;
conductivity:platform = "platform" ;
conductivity:cell_methods = "time: point depth: point" ;
conductivity:valid_min = NaN ;
conductivity:valid_max = NaN ;
conductivity:ancillary_variables = "conductivity_flatline_qc conductivity_range_qc conductivity_gradient_qc conductivity_spike_qc conductivity_qc" ;
byte conductivity_qc(time) ;
conductivity_qc:_FillValue = 9b ;
conductivity_qc:standard_name = "sea_water_electrical_conductivity status_flag" ;
conductivity_qc:long_name = "Conductivity Primary QC" ;
conductivity_qc:flag_values = 1b, 2b, 3b, 4b, 9b ;
conductivity_qc:flag_meanings = "GOOD NOT_EVALUATED SUSPECT BAD MISSING" ;
conductivity_qc:comment = "Primary QC flag" ;
conductivity_qc:coordinates = "time latitude longitude depth" ;
conductivity_qc:source = "Observational data from a buoy" ;
conductivity_qc:platform = "platform" ;
byte conductivity_flatline_qc(time) ;
conductivity_flatline_qc:_FillValue = 9b ;
conductivity_flatline_qc:long_name = "Conductivity Flat Line Test" ;
conductivity_flatline_qc:standard_name = "sea_water_electrical_conductivity status_flag" ;
conductivity_flatline_qc:flag_values = 1b, 2b, 3b, 4b, 9b ;
conductivity_flatline_qc:flag_meanings = "GOOD NOT_EVALUATED SUSPECT BAD MISSING" ;
conductivity_flatline_qc:comment = "When some sensors and/or data collection platforms fail, the result can be a continuously repeated observation of the same value. This test compares the present observation n to a number (REP_CNT_FAIL or REP_CNT_SUSPECT) of previous observations. Observation n is flagged if it has the same value as previous observations within a tolerance value, EPS, to allow for numerical round-off error. Note that historical flags are not changed." ;
conductivity_flatline_qc:references = "http://www.ioos.noaa.gov/qartod/welcome.html" ;
byte conductivity_range_qc(time) ;
conductivity_range_qc:_FillValue = 9b ;
conductivity_range_qc:long_name = "Conductivity Gross Range Test" ;

conductivity_range_qc:standard_name = "sea_water_electrical_conductivity status_flag" ;
conductivity_range_qc:flag_values = 1b, 2b, 3b, 4b, 9b ;
conductivity_range_qc:flag_meanings = "GOOD NOT_EVALUATED SUSPECT BAD MISSING" ;
conductivity_range_qc:comment = "All sensors have a limited output range, and this can form the most rudimentary gross range check. No values less than a minimum value or greater tha n the maximum value the sensor can output (SENSOR_MIN, SENSOR_MAX) are acceptable. Additionally, the operator can select a smaller span (USER_MIN, USER_MAX) based upon local knowledge or a desire to draw attention to extreme values. NOTE: Operators may choose to flag as suspect values that exceed the calibration span but not the hardware limits (e.g., a value that sensor is not capable of producing)." ;
conductivity_range_qc:references = "http://www.ioos.noaa.gov/qartod/welcome.html" ;
byte conductivity_gradient_qc(time) ;
conductivity_gradient_qc:_FillValue = 9b ;
conductivity_gradient_qc:long_name = "Conductivity Rate of Change Test" ;
conductivity_gradient_qc:standard_name = "sea_water_electrical_conductivity status_flag" ;
conductivity_gradient_qc:flag_values = 1b, 2b, 3b, 4b, 9b ;
conductivity_gradient_qc:flag_meanings = "GOOD NOT_EVALUATED SUSPECT BAD MISSING" ;
conductivity_gradient_qc:comment = "This test inspects the time series for a time rate of change that exceeds a threshold value identified by the operator. WL values can change substantially over short periods in some locations, hindering the value of this test. A balance must be found between a threshold set too low, which triggers too many false alarms, and one set too high, making the test ineffective. Test implementation can be challenging. Upon failure, it is unknown which point is bad. Further, upon failing a data point, it remains to be determined how the next iteration can be handled.\nThe following suggest two ways to select the thresholds:\n1) The rate of change between WLn-1 and WLn must be less than three standard deviations (3*SD). The SD of the WL time series is computed over the previous 25-hour period (operator-selected value) to accommodate cyclical diurnal and other tidal fluctuations. The local operator determines both the\nnumber of SDs (N_DEV) and the period over which the SDs are calculated (TIM_DEV).\n 2)\nThe rate of change between WLn-1 and WLn must be less than 0.1 meter +2SD." ;
conductivity_gradient_qc:references = "http://www.ioos.noaa.gov/qartod/welcome.html" ;
byte conductivity_spike_qc(time) ;
conductivity_spike_qc:_FillValue = 9b ;
conductivity_spike_qc:long_name = "Conductivity Spike Test" ;
conductivity_spike_qc:standard_name = "sea_water_electrical_conductivity status_flag" ;
conductivity_spike_qc:flag_values = 1b, 2b, 3b, 4b, 9b ;
conductivity_spike_qc:flag_meanings = "GOOD NOT_EVALUATED SUSPECT BAD MISSING" ;
conductivity_spike_qc:comment = "This check is for single-value spikes, specifically the value at point n-1. Spikes consisting of more than one data point are difficult to capture, but their onset may be flagged by the rate of change test. The spike test consists of two operator-selected thresholds, THRSHLD_LOW and THRSHLD_HIGH. Adjacent data points (n-2 and n0) are averaged to form a spike reference (SPK_REF). The absolute value of the spike is tested to capture positive and negative spikes. Large spikes are easier to identify as outliers and

flag as failures. Smaller spikes may be real and are only flagged suspect. The thresholds may be fixed values or dynamically established (for example, a multiple of the standard deviation over an operator-selected period)." ;

conductivity_spike_qc:references = "http://www.ioos.noaa.gov/qartod/welcome.html" ;

// global attributes:

:comment = "These data include quality flags." ;
:featureType = "timeSeries" ;
:publisher_email = "doug@coastaloceanobs.com" ;
:contributor_role = "Primary Collector, Data Management" ;
:institution = "NOAA Chesapeake Bay Office" ;
:creator_email = "doug@coastaloceanobs.com" ;
:sea_name = "Chesapeake Bay" ;
:date_issued = "2016-02-19 16:20:27.094487+00:00" ;
:cdm_data_type = "Station" ;
:Metadata_Conventions = "Unidata Dataset Discovery v1.0" ;
:creator_url = "http://buoybay.noaa.gov/" ;
:Conventions = "CF-1.6" ;
:publisher_name = "Doug Wilson" ;
:id = "cbibs-WaterQuality_44041_2016-02-05.nc" ;
:naming_authority = "gov.noaa.chesapeakebay" ;
:license = "This data is available for distribution \'as is\' and any express or implied warranties, including, but not limited to, the implied warranties of merchantability and fitness for a particular purpose are disclaimed. In no event shall the data collectors or distributors be liable for any direct, indirect, incidental, special, exemplary, or consequential damages however caused and on any theory of libaility, whether in contract, strict liability, or tort arising in any way out of the use of this data, even if advised of the possibility of such damage." ;
:contributor_name = "NOAA Chesapeake Bay Office, RPS ASA" ;
:keywords_vocabulary = "NASA/GCMD Earth Science Keywords (ACDD)" ;
:acknowledgment = "NOAA Chesapeake Bay Office" ;
:creator_name = "Doug Wilson" ;
:platform = "platform" ;
:standard_name_vocabulary = "NetCDF Climate and Forecast (CF) Metadata Convention Standard Name Table 28" ;
:date_modified = "2016-02-19 16:20:27.094487+00:00" ;
:summary = "Chesapeake Bay Interpretive Buoy System (CBIBS) collected data. These data represent sensor observations collected from several locally deployed sensors in the Chesapeake Bay region. The sensor observations are translated into scientific units, then derived parameters are calculated and included in the dataset. These data include quality flags.\n" ;
:project = "Chesapeake Bay Interpretive Buoy System (CBIBS)" ;
:source = "Observational data from a buoy stored in database" ;
:publisher_url = "http://buoybay.noaa.gov/" ;
:title = "CBIBS Jamestown CBIBS Buoy WaterQuality data from 2016-02-05T00:00:00+00:00 to 2016-03-05T00:00:00+00:00" ;
:processing_level = "Sensor observations, derived parameters and quality control flags." ;
:history = "Telemetry collected by NCBO, Derived Parameters Calculated and Stored, netCDF file generated" ;

:uuid = "660500aa-cb7a-598e-8f9d-ae39e6e0beea" ;
:time_coverage_start = "2016-02-05T00:00:00+00:00" ;
:time_coverage_end = "2016-03-05T00:00:00+00:00" ;
:time_coverage_resolution = "point" ;
:time_coverage_duration = "P29D" ;
:geospatial_lat_min = 37.2042 ;
:geospatial_lat_max = 37.2042 ;
:geospatial_lon_min = -76.7773 ;
:geospatial_lon_max = -76.7773 ;
:geospatial_lat_units = "degrees_north" ;
:geospatial_lon_units = "degrees_east" ;
:geospatial_lat_resolution = "point" ;
:geospatial_lon_resolution = "point" ;
:geospatial_vertical_units = "meters" ;
:geospatial_vertical_positive = "up" ;
:geospatial_vertical_min = 0.f ;
:geospatial_vertical_max = 0.f ;
:keywords = "Oceans > Salinity/Density > Salinity,Oceans > Salinity/Density > Conductivity,Oceans > Ocean Temperature > Water Temperature,Oceans > Ocean Chemistry > Oxygen,Oceans > Ocean Chemistry > Chlorophyll" ;
:date_created = "2016-02-19T16:20:27.852634+00:00" ;
}