Manual for
Real-Time Oceanographic Data Quality Control Flags

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Document Validation

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## Revision History

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<tr>
<th>Date</th>
<th>Revision Description</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>January 2014</td>
<td>Original Document Published</td>
<td></td>
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</table>
| 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)  
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

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


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.

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Quality Flag</td>
<td>Data quality flag is metadata associated with a specific data point indicating the results of one or more QC tests.</td>
</tr>
<tr>
<td>Data Record</td>
<td>A data record is one or more messages that form a coherent, logical, and complete observation.</td>
</tr>
<tr>
<td>Data User</td>
<td>A data user is a middle or endpoint entity desiring information, but not necessarily knowledgeable in methods used to obtain the information.</td>
</tr>
<tr>
<td>Interoperable</td>
<td>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.</td>
</tr>
<tr>
<td>Operator</td>
<td>Operators are individuals or entities who are responsible for collecting and providing data.</td>
</tr>
<tr>
<td>Quality Assurance</td>
<td>QA involves processes that are employed with hardware to support the generation of high quality data.</td>
</tr>
<tr>
<td>Quality Control</td>
<td>QC involves follow-on steps that support the delivery of high quality data and requires both automation and human intervention.</td>
</tr>
<tr>
<td>Real Time</td>
<td>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.</td>
</tr>
<tr>
<td>Summary Flag</td>
<td>Summary flag is a single flag set to the worst case of all QC flags within the data record.</td>
</tr>
</tbody>
</table>
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.

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

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.

<table>
<thead>
<tr>
<th>Flag</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pass=1</td>
<td>Data have passed critical real-time quality control tests and are deemed adequate for use as preliminary data.</td>
</tr>
<tr>
<td>Not evaluated=2</td>
<td>Data have not been QC-tested, or the information on quality is not available.</td>
</tr>
<tr>
<td>Suspect or Of High Interest=3</td>
<td>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.</td>
</tr>
<tr>
<td>Fail=4</td>
<td>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.</td>
</tr>
<tr>
<td>Missing data=9</td>
<td>Data are missing; used as a placeholder.</td>
</tr>
</tbody>
</table>

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).

<table>
<thead>
<tr>
<th>Example of quality control tests and data processing history (IOC 54:V3).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Globally impossible value (exceeds low or high thresholds)</td>
</tr>
<tr>
<td>Monthly climatology standard deviation test (exceeds warning or failure thresholds)</td>
</tr>
<tr>
<td>Excessive spike check (exceeds warning or failure, low or high thresholds)</td>
</tr>
<tr>
<td>Excessive offset/bias when compared to a reference data set (exceeds warning or failure, low or high thresholds)</td>
</tr>
<tr>
<td>Unexpected X/Y ratio (e.g., chemical stoichiometry or property-property X to T, S, density, among others)</td>
</tr>
<tr>
<td>Excessive spatial gradient or pattern check (“bullseyes”)</td>
</tr>
<tr>
<td>Below detection limit of method</td>
</tr>
</tbody>
</table>

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:

```cdl
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). 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 300

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.

<table>
<thead>
<tr>
<th>Bit</th>
<th>Failure/Warning</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Failure</td>
<td>Salinity out of range</td>
</tr>
<tr>
<td>1</td>
<td>Failure</td>
<td>Salinity zero</td>
</tr>
<tr>
<td>2</td>
<td>Failure</td>
<td>Water temperature out of range</td>
</tr>
<tr>
<td>3</td>
<td>Failure</td>
<td>Time is &gt; 6 minutes off</td>
</tr>
<tr>
<td>4</td>
<td>Warning</td>
<td>Salinity is flat</td>
</tr>
<tr>
<td>5</td>
<td>Warning</td>
<td>Water temperature is flat</td>
</tr>
<tr>
<td>6</td>
<td>Failure</td>
<td>No data</td>
</tr>
<tr>
<td>7</td>
<td>Failure</td>
<td>Barometric pressure is out of range</td>
</tr>
<tr>
<td>8</td>
<td>Warning</td>
<td>Barometric pressure is flat</td>
</tr>
<tr>
<td>9</td>
<td>Failure</td>
<td>Water temperature sensor disabled by CORMS²</td>
</tr>
<tr>
<td>10</td>
<td>Failure</td>
<td>Conductivity (salinity) sensor disabled by CORMS</td>
</tr>
</tbody>
</table>

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).

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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 N₀ to examine data point N₋₁. In this case, the flag for the QC test on the data point N₀ should be set to “2 Not evaluatd, not available, or unknown.” After receipt of the subsequent data point, N₀ 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


136 pp. Omni Hotel, Atlanta, Georgia.  
http://nautilus.baruch.sc.edu/twiki/pub/Main/WebHome/QARTOD_final_09.pdf


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
## Appendix A.  QARTOD Data QC Flag Manual Team

### QARTOD Data QC Flag Manual Reviewers, Version 1.1

<table>
<thead>
<tr>
<th>Name</th>
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<tbody>
<tr>
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<td>NANOOS/University of Washington</td>
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### U.S. IOOS Regional Associations, Version 1.1

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<td>GLOS</td>
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### QARTOD Board of Advisors, Version 1.1

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<tr>
<td>Kathleen Bailey – Project Manager</td>
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</tr>
<tr>
<td>Julie Bosch</td>
<td>NOAA/National Centers for Environmental Information</td>
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<tr>
<td>Eugene Burger</td>
<td>NOAA/Pacific Marine Environmental Laboratory</td>
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<td>Janet Fredericks</td>
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<td>Matt Howard</td>
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<tr>
<td>Chris Paternostro</td>
<td>NOS/CO-OPS</td>
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<tr>
<td>Mario Tamburri</td>
<td>University of Maryland Center for Environmental Science / Chesapeake Biological Laboratory</td>
</tr>
<tr>
<td>Julie Thomas – BOA Chair</td>
<td>SCCOOS/ Scripps Institution of Oceanography/Coastal Data Information Program</td>
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# DMAC Community, Version 1.1

## Regional Associations

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<td>Roy Watlington</td>
<td>Debra Hernandez</td>
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## Research Organizations

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<td>Darren Wright</td>
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<tr>
<td>Monterey Bay Aquarium Research Institute</td>
<td>Smithsonian Environmental Research Center</td>
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<tr>
<td>Aric Bickel</td>
<td>Matthew Ogburn</td>
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<td>Anderson David</td>
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<td>Fred Bahr</td>
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## Federal and State Agencies

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<td>Jonathan Blythe</td>
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<td>Great Lakes Commission</td>
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<td>Guan Wang</td>
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## 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 |
| Jennifer Rhoades | Xiaoyan Li |

## U.S. Army Corps of Engineers

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<th>Jeff Lillycrop</th>
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<td>Jonathan Pye</td>
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### Data QC Flag Manual Editors, Version 1.0

<table>
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<tr>
<td>Mark Bushnell, Lead</td>
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</tr>
<tr>
<td>Ray Toll</td>
<td>Old Dominion University/NDBC</td>
</tr>
<tr>
<td>Helen Worthington</td>
<td>REMSA/CO-OPS</td>
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### Data QC Flag Manual Reviewers/DMAC Committee, Version 1.0

<table>
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<tr>
<td>Rob Bochenek</td>
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Appendix B. Implementation Example for netCDF Flags

```c
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_lon` 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_meaning = "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 vary 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 than 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 than 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_gradient_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_spike_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"
```

The following suggest two ways to select the thresholds:

1) 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 number of SDs (N_DEV) and the period over which the SDs are calculated (TIM_DEV).

2) The rate of change between WLn-1 and WLn must be less than 0.1 meter +2SD.
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_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."

"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"

"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"

"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_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 than 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 WL_{n-1} and WL_{n} 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 number of SDs (N_DEV) and the period over which the SDs are calculated (TIM_DEV).\n2) The rate of change between WL_{n-1} and WL_{n} 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 MISSIMG";

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, THRESHLD_LOW and THRESHLD_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 MISSIMG"
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 than 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_temperaturegradient_qc(time);
water_temperaturegradient_qc:_FillValue = 9b;
water_temperaturegradient_qc:long_name = "Water Temperature Rate of Change Test";
water_temperaturegradient_qc:standard_name = "sea_water_temperature status_flag";
water_temperaturegradient_qc:flag_values = 1b, 2b, 3b, 4b, 9b;
water_temperaturegradient_qc:flag_meanings = "GOOD NOT_EVALUATED SUSPECT BAD MISSING";
water_temperaturegradient_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. The following suggest two ways to select the thresholds:

1) The rate of change between WL_n-1 and WL_n 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 number of SDs (N_DEV) and the period over which the SDs are calculated (TIM_DEV).

2) The rate of change between WL_n-1 and WL_n must be less than 0.1 meter +2SD.";
water_temperaturegradient_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: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" ;
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 than 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. The following suggest two ways to select the thresholds:
1) 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 number of SDs (N_DEV) and the period over which the SDs are calculated (TIM_DEV). 2) The 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";
concentration_range_qc:standard_name = "sea_water_electrical_conductivity"
status_flag",
concentration_range_qc:flag_values = 1b, 2b, 3b, 4b, 9b;
concentration_range_qc:flag_meanings = "GOOD NOT_EVALUATED SUSPECT BAD MISSING";
concentration_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 than 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).";
concentration_range_qc:references = "http://www.ioos.noaa.gov/qartod/welcome.html";
byte concentration_gradient_qc(time);
concentration_gradient_qc:_FillValue = 9b;
concentration_gradient_qc:long_name = "Conductivity Rate of Change Test";
concentration_gradient_qc:standard_name = "sea_water_electrical_conductivity"
status_flag",
concentration_gradient_qc:flag_values = 1b, 2b, 3b, 4b, 9b;
concentration_gradient_qc:flag_meanings = "GOOD NOT_EVALUATED SUSPECT BAD MISSING";
concentration_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. The following suggest two ways to select the thresholds: 1) 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 number of SDs (N_DEV) and the period over which the SDs are calculated (TIM_DEV). 2) The rate of change between WLn-1 and WLn must be less than 0.1 meter +2SD."
concentration_gradient_qc:references = "http://www.ioos.noaa.gov/qartod/welcome.html";
byte concentration_spike_qc(time);
concentration_spike_qc:_FillValue = 9b;
concentration_spike_qc:long_name = "Conductivity Spike Test";
concentration_spike_qc:standard_name = "sea_water_electrical_conductivity"
status_flag",
concentration_spike_qc:flag_values = 1b, 2b, 3b, 4b, 9b;
concentration_spike_qc:flag_meanings = "GOOD NOT_EVALUATED SUSPECT BAD MISSING";
concentration_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 liability, 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."

```
: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"
```
Data QC Flags Manual

: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" ;
}