

APPENDIX F

QUALITY CONTROL AND QARTOD APPLICATIONS TO AOOS REGIONAL DATA STREAMS

QARTOD and Quality Control Tests Implementation

The AOOS Data System employs fundamental data quality control prior to making data available on its data portals. Two of the three standard AOOS tests meet QARTOD implementation guidelines, and are described in this section and in the Regional Data Stream Plans. Additional QARTOD tests that may be required but not currently implemented are either exempt with reasons provided in the Regional Data Stream Plans, or will be implemented in a phased rollout within 12 months of NOAA Certification process.

Data streams that currently require QARTOD implementation (and associated web links to manuals) at the time of this version (August 2016) of the Data System Management Plan include:

- [Real-Time Quality Control of HF Radar Observations](#)
- [Real-Time Quality Control of Dissolved Nutrients Observations](#)
- [Real-Time Quality Control of Wind Data](#)
- [Real-Time Quality Control of Water Level Data](#)
- [Real-Time Quality Control of In-Situ Surface Wave Data](#)
- [Real-Time Quality Control of Ocean Optics Data](#)
- [Real-Time Quality Control of In-Situ Temperature and Salinity Data](#)
- [Real-Time Quality Control of Dissolved Oxygen Observations in Coastal Oceans](#)
- [Real-Time Quality Control of In-Situ Current Observations](#)
- [Manual for Oceanographic Data Quality Control Flags](#)

The key objective of QARTOD is to sustain a process for establishing QA/QC procedures of IOOS and participating Regional Associations' non-federal assets that will:

- Establish authoritative QA/QC procedures for 26 of the [U.S. IOOS core variables](#), as necessary, including detailed information about the sensors and procedures used to measure the variables;
- Produce written manuals for these QA/QC procedures;
- From the list of individual QA/QC procedures and guidelines developed, define a baseline set of QA/QC procedures that can be used for certification of RCOOS data providers;
- Facilitate QA/QC integration with Global Ocean Observing System (GOOS) and other international ocean observation efforts;
- Engage the Federal Agencies and IOOS Regions that are part of, or contribute to, US IOOS who will use the established QA/QC procedure;

- Work efficiently, without duplication of effort, to facilitate the implementation of common QA/QC procedures amongst US IOOS Partners.

As of June 30, 2016, AOOS offers real-time data for five data streams requiring QARTOD implementation:

- Wind
- In-situ surface waves
- Water level data
- HFR data
- In-situ temperature data

Data flags (Table 1) required by QARTOD will be implemented within 12 months of certification on Regional Data Streams that require QC flags. Additional QC flags may be attributed to data as additional QC testing is provided (or conducted by the data provider). These additional flags will be updated and documented in the individual Regional Data Stream Plans when they are implemented.

Table 1. Flags for real-time data based on UNESCO (2013) standards.

FLAG	DESCRIPTION
Pass = 1	Data have passed critical real-time quality control tests as outlined in the Data Stream Plan, and are deemed adequate for use as preliminary data.
Not Evaluated = 2	Data have not been QC-tested in any way, or the information on quality is not available.
Suspect or High Interest = 3	Data are either suspect or of high interest to data providers and users. This flag is to draw particular attention by the operators.
Fail = 4	Data are considered inadequate for inclusion in critical operational analysis because they have failed one or more critical real-time QC checks. This flag is to warn the provider and the user that these data have not met QC tests, and may not meet minimum standards to be considered accurate. This flag is used when QC Failed data are left in the record.
Missing Data == 9	Data are missing; Used as a placeholder (NaN)

This appendix will be updated as more QARTOD applications become available or change, and when AOOS adds a real-time data stream not described here. Regardless, individual data stream plans will contain all the necessary QARTOD application information for any real-time data stream.

QARTOD Weather Data QC Implementation: Real-time QC will be conducted on the following wind parameters, as described in the QARTOD manual for weather parameters:
<https://www.ioos.noaa.gov/ioos-in-action/wind-data/>

- Wind Speed
- Wind Direction
- Wind Gust

There are five required tests for these weather parameters outlined in the QARTOD application, of which three are already implemented by the AOOS Data System -- the syntax, gross range and time gap tests. QARTOD requires three additional tests -- a timing gap test that flags missing data points, location test and climatology test. A version of the Timing Gap Test, which with QARTOD is intended to ensure ingestion of minimum hourly time series, is performed by AOOS. The AOOS version of the timing gap test changes the station color to a grey shade ("shade-flags") on the real-time sensor map display after 4 hours of missed data reports, and removes the station from the map (though not the archive) after a week of missed reports. The Location Test will be implemented when there is a GPS (latitude and longitude) location provided as part of the station data stream (e.g., on a buoy). Most nonfederal weather data offered by AOOS originate on land-based (fixed) platforms, and location data feeds are typically unavailable, eliminating the need for this test. The Climatology Test is more rigorous, and currently, the AOOS Data System does not have the historical data in place to perform meaningful climatology tests on non-federal sourced weather assets. It is a test that may be considered after there are 7+ years of data in the AOOS archive.

At least one regional weather station is from a community observer asset (Alyeska Resort G-7), and QC is not required; however, if possible, to increase the usefulness of such assets, more rigorous QARTOD checks may be implemented regardless, and when possible, data quality assurance of these assets will be documented (e.g., installation, maintenance and validation procedures). Please refer to the Regional Data Stream plans for more details on QC protocols for specific weather data assets in Appendix G (G-5, G-7, G-11).

QARTOD In-situ Surface Wave Data QC Implementation: Real-time QC will be conducted on the following parameters, as described in the QARTOD manual for in-situ surface wave data:

https://www.ioos.noaa.gov/wp-content/uploads/2016/04/qartod_water_level_manual.pdf

- Wave Height
- Wave Direction
- Wave Period
- Average Wave Period
- Wave Spreading
- Wave Spectra (Energy Density)

QARTOD requires five QC tests on wave data, two of which are frequency tests only required if reporting out wave spectra data. AOOS already performs a syntax, gross range and time gap test on bulk wave parameters, (except wave period). The AOOS timing gap test changes the station color to a grey shade (“shade-flags”) on the real-time sensors map display after 4 hours of missed data reports, and removes the station from the map (though not the archive) after a week of missed reports. QARTOD’s timing gap test differs slightly from the AOOS test, and flags missing data points, which is intended to ensure ingestion of minimum hourly time series.

Four potential QARTOD tests remain open for implementation:

- A more rigorous time gap check on all parameters that flags missing records;
- Gross Range test for Wave Period;
- Long-Term Time series flat line test (Test 16), which tests for invariate observations (continuous repeated observations of the same value for prolonged period of time);
- Long-Term Time series rate of change test (Test 20) (similar to a spike test), which evaluates the rate of change with time using a maximum limit for the rate of change between successive data points.

AOOS will implement the remaining Group 1 required QARTOD QC checks and will continue the two QC tests already performed automatically by AOOS (Syntax and Gross Range tests) on all real-time wave data assets that do not originate from a federal source or an exempt data network provider (e.g., CDIP).

QARTOD Water Level Data QC Implementation: Real-Time QC will be conducted on parameters as described in the QARTOD manual for water level data

https://www.ioos.noaa.gov/wp-content/uploads/2016/04/qartod_water_level_manual.pdf).

QARTOD requires five tests for real-time water level data reporting, of which three are already implemented by the AOOS Data System -- the syntax, gross range and time gap tests. QARTOD requires three additional tests including a timing gap test that flags missing data points, location test and climatology test. A version of the Timing Gap Test, which with QARTOD, is intended to ensure ingestion of minimum hourly time series, is performed by AOOS. The AOOS version of the timing gap test changes the station color to a grey shade ("shade-flags") on the real-time sensors map display after 4 hours of missed data reports, and removes the station from the map (though not the archive) after a week of missed reports. The Location Test will be implemented when there is a GPS (latitude and longitude) location provided as part of the station data stream (e.g., on a buoy). Some of the non-federal water level data may originate from fixed platforms, such as bridges, and location data feeds may, therefore, be unavailable, eliminating the need for this test. The Climatology Test is more rigorous, and currently, the AOOS Data System does not have the historical data in place to perform meaningful climatology tests on non-federal sourced water level assets. It is a test that may be considered after there are 7+ years of data in the AOOS archive. Please refer to the Regional Data Stream plans for more details on QC protocols for water level data assets in Appendix G (e.g., G-40).

QARTOD HFR Data QC Implementation: Real-Time QC will be conducted as described in the QARTOD manual for High Frequency Radar derived surface current data:

https://ioos.noaa.gov/wp-content/uploads/2016/06/HFR_QARTOD_Manual_05_26_16.pdf).

A total of seven QC tests for HFR derived surface currents are required by QARTOD:

- Signal-to-noise ratio test to ensure the measured signal is sufficiently above a noise level;
- Syntax test;
- Max threshold test to ensure radial current speed is not unrealistically high;
- Valid location test (radial components), to remove radial vectors that get placed over land or in other unmeasurable areas;
- Data density threshold to check a sufficient number of radial velocities exist to compute a total velocity vector;
- GDOP threshold that tests uncertainty in velocity due to geometric relationship between radials is low enough for the vector to be valid;
- Max speed threshold to ensure total current speed is not unreasonably high.

The Alaska HFR data served by AOOS are and will continue to be acquired from the National IOOS HFR data server at Coastal Observation Research and Development Center University of California San Diego (UCSD). UCSD acquires the HFR data directly from the University of Alaska Fairbanks (UAF), QC is performed, and data are converted to NetCDF format. The following link provides the QC documentation on the UCSD website that describes the quality control performed on HFR Network data:

http://cordc.ucsd.edu/projects/mapping/documents/HFRNet_QC-RTVproc.pdf

As long as these data are processed and accessed through the HFR Network, they do not require additional QC or QARTOD QC implementations by AOOS.

QARTOD In-situ Temperature and Salinity Data QC Implementation: Real-time QC will be conducted as described in the QARTOD manual for in-situ temperature and salinity data.

https://www.ioos.noaa.gov/wp-content/uploads/2016/04/qartod_temperature_salinity_manual.pdf

There are five required tests for in-situ temperature and salinity identified by QARTOD, of which three are currently implemented by the AOOS Data System -- the syntax, gross range, and time gap tests. QARTOD requires two additional tests including a timing gap test that flags missing data points, location test and climatology test. A version of the Timing Gap Test, which with QARTOD, is intended to ensure ingestion of minimum hourly time series, is performed by AOOS. The AOOS version of the timing gap test changes the station color to a grey shade ("shade-flags") on the real-time sensors map display after 4 hours of missed data reports, and removes the station from the map (though not the archive) after a week of missed reports. The Location Test will be implemented when there is a GPS (latitude and longitude) location provided in the station data stream, as might be the case on a moored buoy. The Climatology Test is more rigorous, and currently, the AOOS Data System does not have the historical data in place to perform meaningful climatology tests on non-federal sourced weather assets. It is a test that may be considered after there are 7+ years of data in the AOOS archive. Please refer to Appendices G for QC protocols planned for any AOOS real-time temperature and salinity observations (e.g., G-16, G-17 G-23, G-37).