Ocean Sciences, Portland, OR, Feb 11-16, 2018 Session OD24C Poster #2736 Abstract #323351

Real-time Quality Control of High Frequency Radar Data

Teresa G. Updyke[1], Hugh J. Roarty[2], Larry P. Atkinson[1]

[1]*Center for Coastal Physical Oceanography, Old Dominion University, Norfolk, VA, USA*
[2]*Center for Ocean Observing Leadership, Rutgers University, New Brunswick, NJ, USA.*

Introduction

The QARTOD Manual for Real-Time Quality Control of High Frequency Radar Surface Current Data describes several QC tests that may be performed at different levels of HF radar data processing [1]. Each of these tests has a designation: required, strongly recommended, suggested or in development. (Table 1). The Ocean Observatories Initiative also describes six QC tests with some overlap: global range, local range, spike, stuck value, gradient and trend [2]. The Integrated Ocean Observing System (IOOS) regional associations have already implemented or are in the process of implementing the QARTOD required tests. This poster focuses on QC tests at the radial level using examples from radar stations in the Mid-Atlantic region.

Data	Test	Status
Radials	**Syntax**	**Required**
	Max Threshold	**Required**
	Valid Location	**Required**
	Radial Count	Suggested
	Spatial Median Filter	Suggested
	Temporal Gradient	Suggested
	Average Radial Bearing	Suggested
	Synthetic Radial	In development
Totals	**Data Density Threshold**	**Required**
	GDOP Threshold	**Required**
	Max Speed Threshold	**Required**
	Spatial Median Comparison	Suggested

Table 1. List of QARTOD QC tests for radials and total vectors. Spectral processing QC tests are not shown.

Automated QC

The Mid-Atlantic Regional Association Coastal Ocean Observing System (MARACOOS) has performed initial operational QC testing on radial data by creating quality controlled files for CODAR Oceans Sensors SeaSonde data that include individual QC test flags and a summary flag (Fig. 1). Both levels of flags follow the IOC 54:V3 Primary Level flagging standard (UNESCO 2013) which has been adopted by QARTOD [3].

```
%QCFlagReference: Quality control reference: IOOS QARTOD HF Radar ver 1.0 May 2016
%QCFlagDefinitions: 1=Pass 2=Not Evaluated 3=Suspect 4=Fail 9=Missing Data
%QCTimespan: current file + 2 before and after
%GRNGFlagThresholds: GlobalRange=300
%STCKFlagThresholds: stuck_resolution=0.01 stuck_num=3
%GRADFlagThresholds: gradient_threshold=0.005
%TableColumns: 22
%TableColumnTypes: LOND LATD VELU VELV VFLG ESPC ETMP MAXV MINV ERSC ERTC XDST YDST RNGE BEAR VELO HEAD SPRC  GRNG STCK GRAD SFLG
. . .
%%   Longitude   Latitude    U comp   V comp  VectorFlag |   Range   Bearing   Velocity  Direction  Spectra   Global    StuckSnsr  Gradient  Summary
%%     (deg)       (deg)     (cm/s)   (cm/s)  (GridCode  |    (km)    (True)    (cm/s)    (True)   RngCell  Rng Flag    Flag       Flag      Flag
-75.9226333 36.7442063   0.000   25.124        0        |  5.8249       0.0    -25.124     180.0        1         1         1          1         1
-75.9169489 36.7440064   2.455   28.044        0        |  5.8249       5.0    -28.151     185.0        1         1         1          1         1
-75.9113078 36.7434083   4.179   23.682        0        |  5.8249      10.0    -24.048     190.0        1         1         1          1         1
-75.9057531 36.7424166   1.699    6.336        0        |  5.8249      15.0     -6.560     195.0        1         1         1          1         1
```

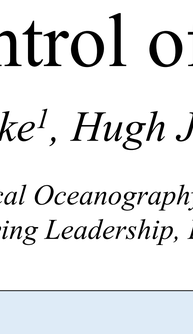
Opted for one column per test instead of binary or hex code scheme to locate multiple flags in a single column.

For future version of file, consider the case where an entire file fails based on a test such as syntax: set flag in the header or flag every vector in the file?

Figure 1. Example of a quality controlled radial file.

An analysis of the flags in these files for the time period of March 1 to December 31, 2017 is presented here. As seen in Figures 2 and 3, percentages of vectors that fail these tests are typically under 5%. The stuck sensor test generally fails more radials than the gradient test. However, the gradient test is failing more radials at southern sites where the Gulf Stream current enters the data coverage area. A look at the timing (Fig. 3) as well as the most frequently flagged locations (Fig. 4) can provide insight into the nature of a QC problem or indicate if threshold values need adjustment for particular areas.

Test Name	Code	Description
Global Range	GRNG	Fails if velocity > 300 cm/s
Stuck Sensor	STCK	Fails if velocity is within 0.01 cm/s for 3 successive values
Gradient	GRAD	Fails if difference between velocity and previous velocity > 0.005 m/s² AND difference between velocity and subsequent velocity > 0.005 cm/s²
Summary	SUMM	Fails if any required test fails. Set to "suspect" if any non-required test fails.



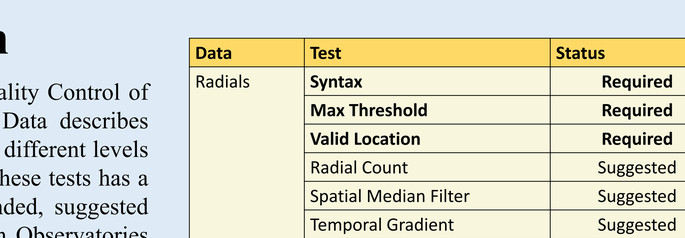


Figure 2. Average percentage of vectors flagged in each file. Results are displayed for eight long range radar sites (site locations shown on map).*

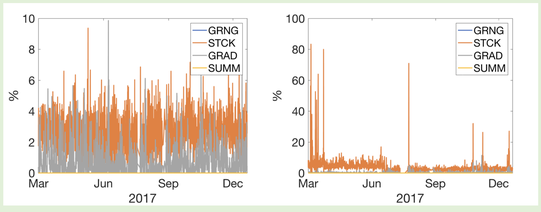


Figure 3. Percentage of vectors failing QC tests at the LISL (left panel) and LOVE (right panel) radar stations. Note the different scales. At LOVE, the spikes occurred during times when the radar transmitter was frequently turning off due to a GPS problem.*

**For this analysis, only vectors with valid locations are considered. Vectors placed over land or in areas where the radar's view is obstructed by land are not included.*

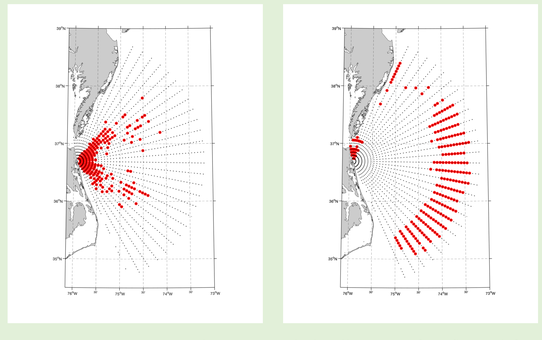


Figure 4. LISL measured pattern radial cells most often flagged for the STCK (left panel) and GRAD (right panel) tests. Black dots are locations that received at least one flag; red dots indicate a flag occurrence above the 0.8 level of the flag count cumulative distribution.

Spatial QC Test

The spatial median filter test is based on a CODAR SeaSonde spatial filter. In this implementation (Fig. 5), a radial velocity is flagged if it differs by more than 30 cm/s from the median value of neighboring velocities (located within a radius of 12 km and bearing of 10 degrees of that radial).

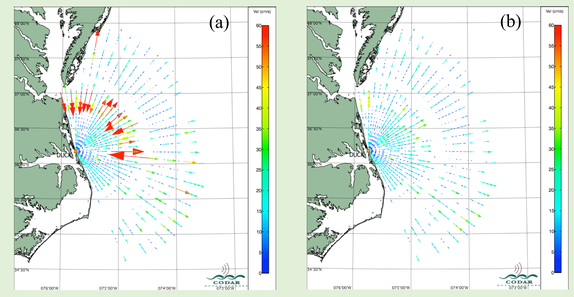


Figure 5. DUCK station radial data for November 9, 2016 23:00 UTC (a) Original map. (b) Map displaying radials that pass the spatial median test.

QC Test Thresholds

Thresholds may be location dependent. For example, the average and standard deviation of temporal gradient can vary enough within a site's coverage area that multiple thresholds would be appropriate (Fig. 6).

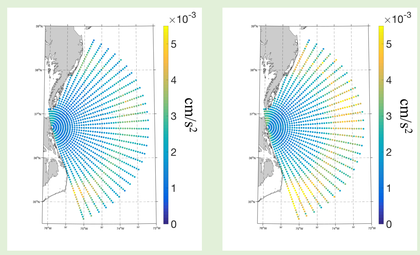


Figure 6. Average (left panel) and standard deviation (right panel) of the temporal gradient using LISL ideal pattern radials from May 10 – July 11 2016.

Thresholds for a low radial count test will be different depending on the station. One approach is to set the failure threshold at 10% of the number of valid radial locations and the suspect threshold at 30%.

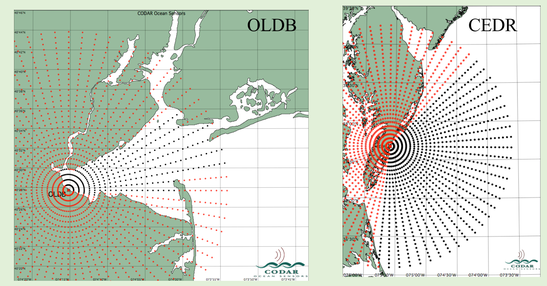


Figure 7. Black grid points represent valid locations for radial data.

Operator QC

Real-time automated QC cannot easily handle all quality problems. For example, changes in measured pattern radial distribution plots (Fig. 8) could indicate that a pattern calibration in use at a site is no longer valid.

MARACOOS radar operators use a web interface to remove a site's radials from the regional total vector processing if the data look suspect. This interface also alerts the National Network to make the same processing change.

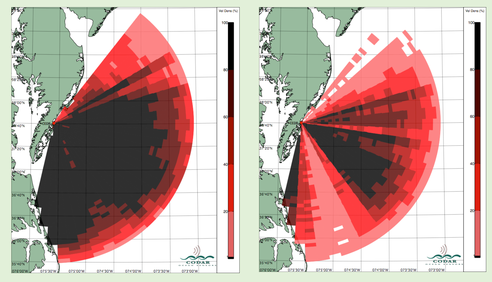


Figure 8. CEDR station measured pattern radial distributions for the weeks of Jan 28-Feb 3 2017 (left) and Apr 10-16, 2017 (right). The colors represent the percent density of radials in each radial grid cell.

Conclusions

Testing to date has shown that small percentages of radial vectors are flagged. Further evaluation, including analysis of the timing and locations of failure flags, for all of the suggested and "in development" quality control tests is needed. Spatial as well as temporal QC tests are beneficial for HF radar data. Depending on the type of test (i.e. temporal gradient), more than one threshold value may be required for a single station or a conservative value must be used to avoid flagging valid data. Automated QC does not preclude the need for frequent operator checks of diagnostics, radial maps and radial distributions.

References

[1] Manual for Real-Time Quality Control of High Frequency Radar Surface Current Data: a Guide to Quality Control and Quality Assurance for High Frequency Radar Surface Current Observations. Version 1.0. Integrated Ocean Observing System (U.S.), U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service, Integrated Ocean Observing System, Silver Spring, MD, 2016.
[2] http://oceanobservatories.org/quality-control/
[3] Manual for the Use of Real-Time Oceanographic Data Quality Control Flags. Version 1.1. Integrated Ocean Observing System (U.S.), U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service, Integrated Ocean Observing System, Silver Spring, MD, 2017.

Further information is available at these websites:
http://www.ccpo.odu.edu/currentmapping https://maracoos.org/
http://cordc.ucsd.edu/projects/mapping

ACKNOWLEDGMENTS
This project is supported by NOAA's Integrated Ocean Observing System (IOOS) through the Mid-Atlantic Regional Association Coastal Ocean Observing System (MARACOOS). We thank the University of North Carolina and Coastal Studies Institute for use of HF radar data from the North Carolina radar stations.