A Unified Approach to HF Radar Data Quality Control for UGOS

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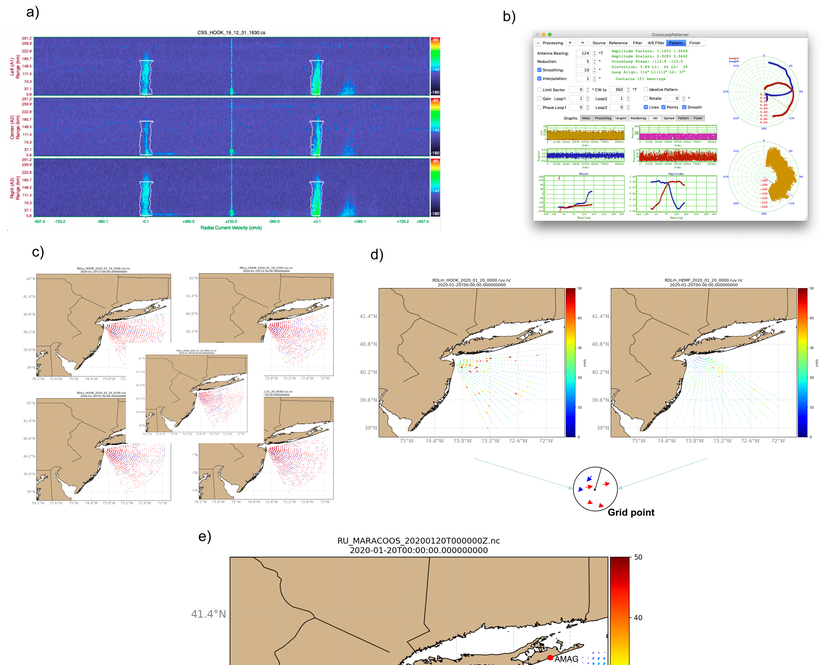
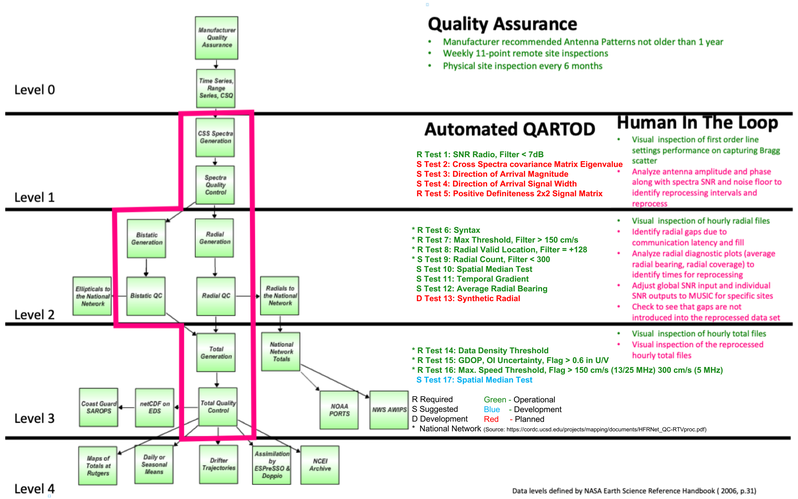
Standard High Frequency Radar Processing Routine



Above: HF Radar Processing Routine. (a) velocities from first order sea echo are extracted from Doppler spectra, (b) Direction finding: Antenna beam pattern is used to place velocities in directional bins within each range cell. (c) Five radial shorts (+/- 75 minutes around the center time) are merged to generate a radial map for a specific hour. (d) Distinct radial sites are combined into a total vector map. All points lying inside of a circle around a grid point are utilized in making the total vector map. (e) The completed total vector map.

UGOS High Frequency Radar Processing Routine

HF Radar Data Real Time & Delayed Mode Flow Chart



Above: UGOS HF Radar Processing Routine. Real-time is displayed in green. Delayed mode is displayed in pink.

CODAR Processing Toolbox

Rutgers has developed an open-source Python toolbox for parsing CODAR Columnar Table Format (CTF). The toolbox is hosted at: github.com/rucool/codar_processing

Features

1.Automatically reads all CTF filetypes (Radials, Waves, Totals, Diagnostics)
- The toolbox also can load radial files from WERA HF radars

2.Both temporal and spatial aggregation depending on filetype

3.Quality Control (QC) Tests
- All required/suggested radial tests described in the QARTOD HFR manual are implemented
- New QC tests can be easily added

4.NetCDF4 Output
- CF 1.6/NCEI Grid 2.0 compliant
- Required for long-term storage and integration of data into models

5.Data Investigation
- The data format can be used to easily investigate (cleaning, grouping, averaging, etc.) data both spatially and temporally.

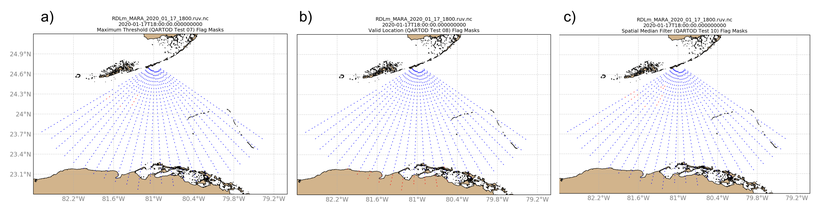
6.Database insertion
- MySQL (relational)
- MongoDB (document storage)

Users/Contributors

We hope this open source code will be adopted by the HF Radar community as a standard way to analyze and execute quality control on HF radar datasets. Currently, the code is being utilized in real-time by the following:

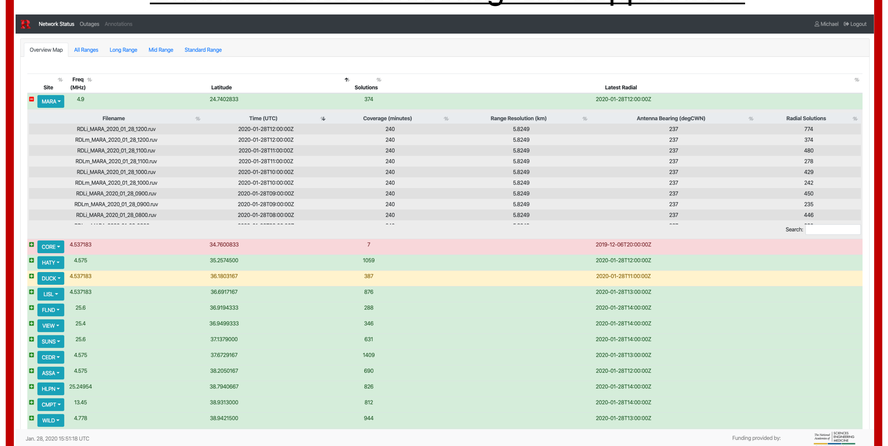
- Mid-Atlantic Regional Association Coastal Ocean Observing System (MARACOOS)
- SWARM (Palmer Deep, Antarctica)
- Old Dominion University – Center for Coastal Physical Oceanography
- Axiom Data Science

QC Flag Results



Above: Quality Controlled Radial Vector Maps of Marathon, FL site. Blue is passing. Red is failing. a) Maximum Threshold Test (red > 120 cm/s) b) Valid Location Test. c) Spatial Median Filter (Range Cell Limit = 2.1, Angular Limit = 10deg, Current Difference = 30cm/s)

Radar Admin Processing Web Application



Above: Radar Admin Web Interface. This interface utilizes a MongoDB backend to provide network and processing status to a user. The main page displays the latest radial information for each site specified in the network. Outages are where operators report site issues (hardware or software). Data Annotations are where information regarding pass, suspect, or failing data is entered. Annotations are then used to inform the delayed mode reprocessing effort.

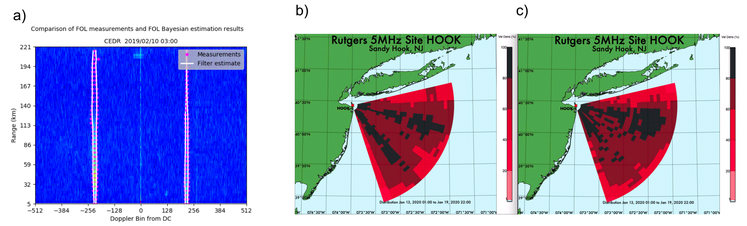
Low-level Data Quality Control

First Order Lines (FOL) Tracking

- Python toolbox utilized to track the changes in FOL through time, range, and doppler bins
- Variability of FOL can be used to monitor changes in strong currents.
- Can be used to diagnose how well the real-time FOL are performing on remote sites.

Automatic Antenna Pattern Measurements using Vessel Tracks (AIS)

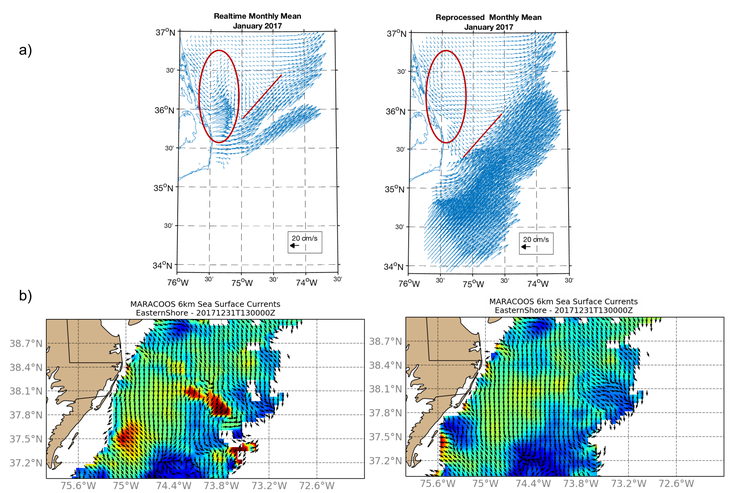
- Testing new software developed at CODAR on our HOOK site
- Site utilizes a machine learning algorithm to pick out ship echoes in cross spectra and match them with known range and velocity of AIS detections to get a bearing.
- Use the antenna ratios from multiple ship peaks to generate an antenna pattern if the algorithm determines that the old pattern is invalid.
- If algorithm determines a new pattern is needed, it produces a report stating why it's invalid.



Above: Low-level Data QC (a) Comparison of Bragg peaks tracked utilizing a Bayesian filter with the real-time FOL settings. (b-c) Radial Distributions (2020/01/13 to 2020/01/19) for Sandy Hook, NJ site. User generated AIS pattern (b) vs automatic pattern software (c). The automated pattern shows a more even radial distribution compared to the spokes of the user generated pattern on the left.

Delayed Mode Processing results

Leveraging our existing Mid-Atlantic radar network for testing the quality control (QC) code, delayed-mode processing significantly improved data quality
- Net Addition of 7,702 radial files (5.9%) increase
- Addition of 11,237 missing radial files
- Removal of 3,535 radial files with questionable data quality
- Diagnostics were reviewed to confirm proper hardware operation
- Valid antenna pattern were applied throughout the year
- 38% of radial files were reprocessed from spectra
- 14% more radials were flagged with additional QARTOD tests
- Radial Metric QC was used on-site for North Carolina stations (Haines et al, 2017)



Above: Delayed mode results. Significant differences (10s of cm/s) can exist between real-time and reprocessed surface current velocities. Comparisons of hourly maps and monthly average maps have shown improvements in (a) data coverage and (b) fewer outliers in the reprocessed product

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