Real-Time Quality Control of Current Velocity Data on Individual Grid Cells in WERA HF Radar

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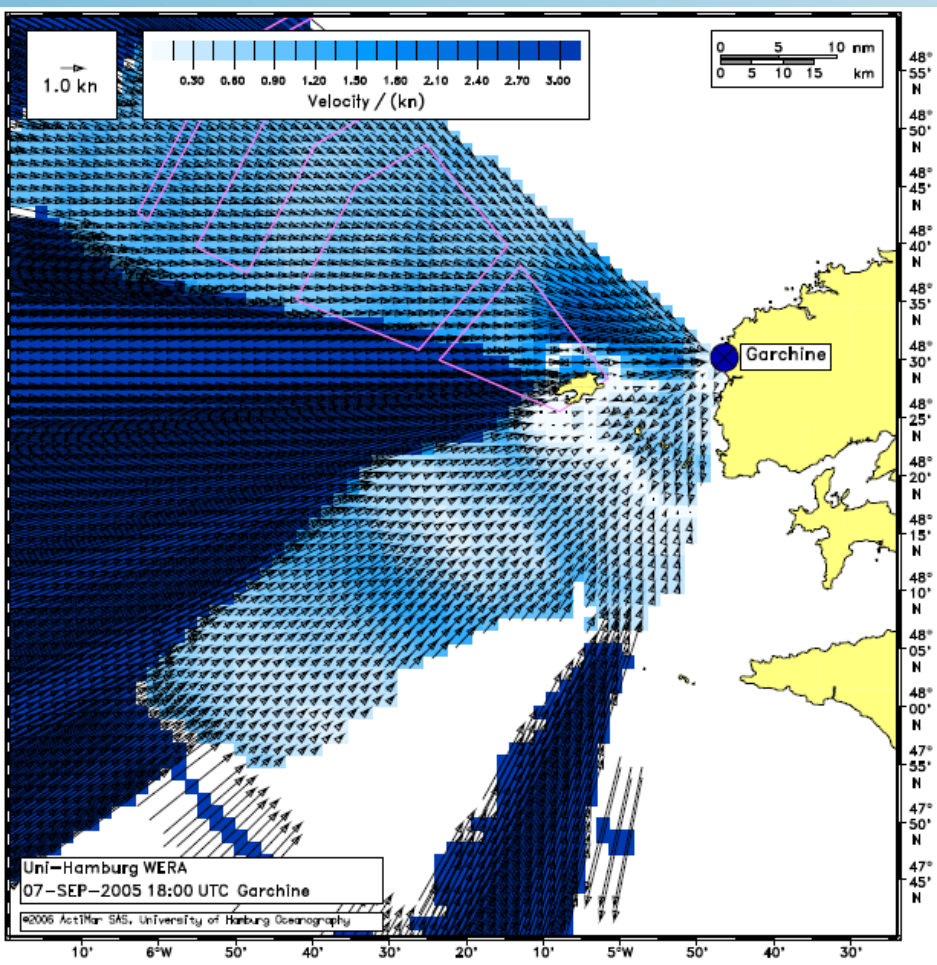
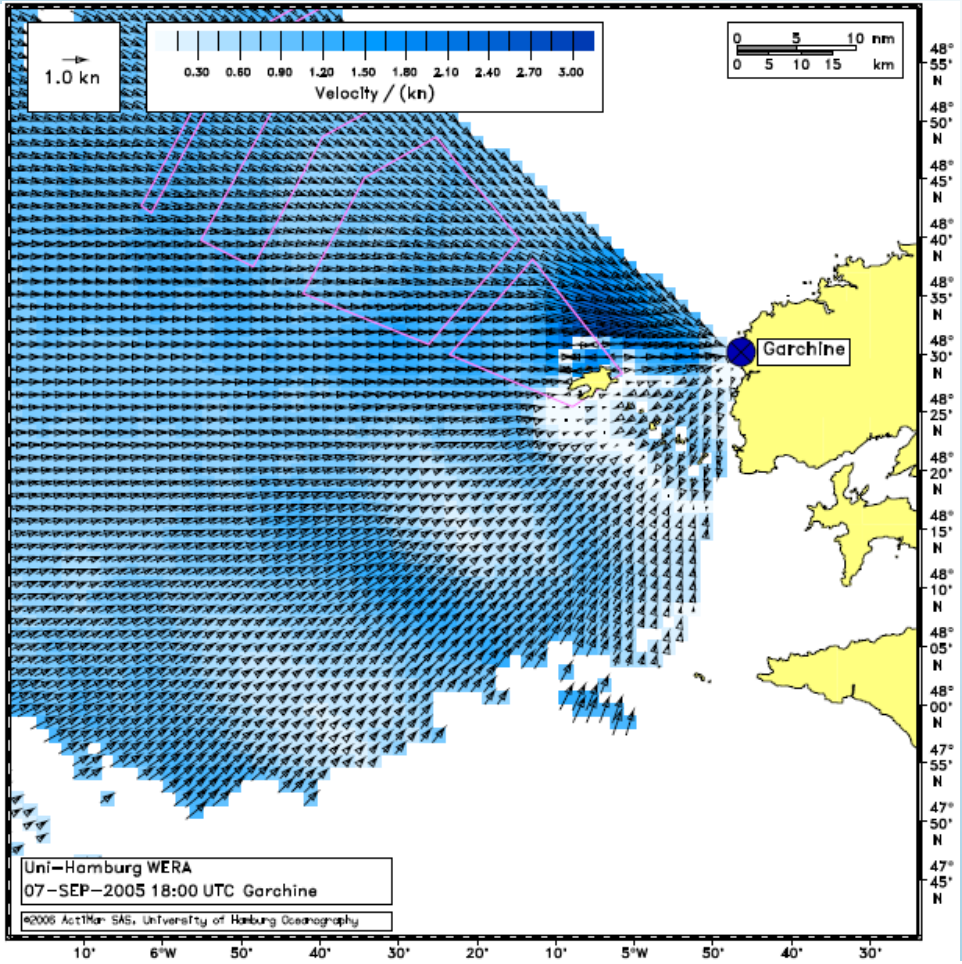
member of maritimes cluster schleswig-holstein and GMT

Contents

Contents

1. Introduction



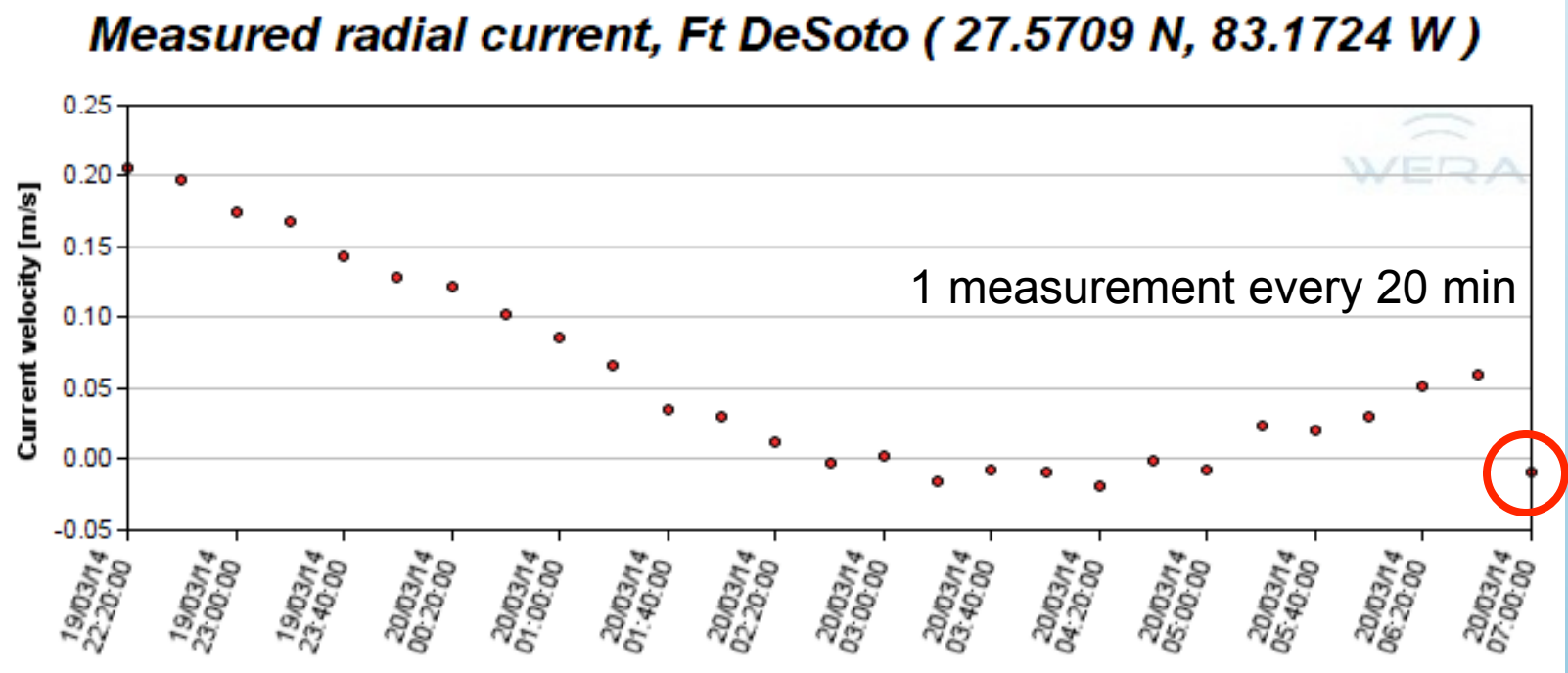


Radio Frequency Interference Suppression Techniques in FMCW Modulated HF Radars,
Gurgel, Barbin, Schlick: Proceedings of IEEE Oceanic Engineering Society Oceans 2007 Europe , 2007

1. Introduction

Even with the best methods to reduce radio interference some suspicious data points remain in the maps from time to time.

The challenge is to identify corrupted data points in real-time.

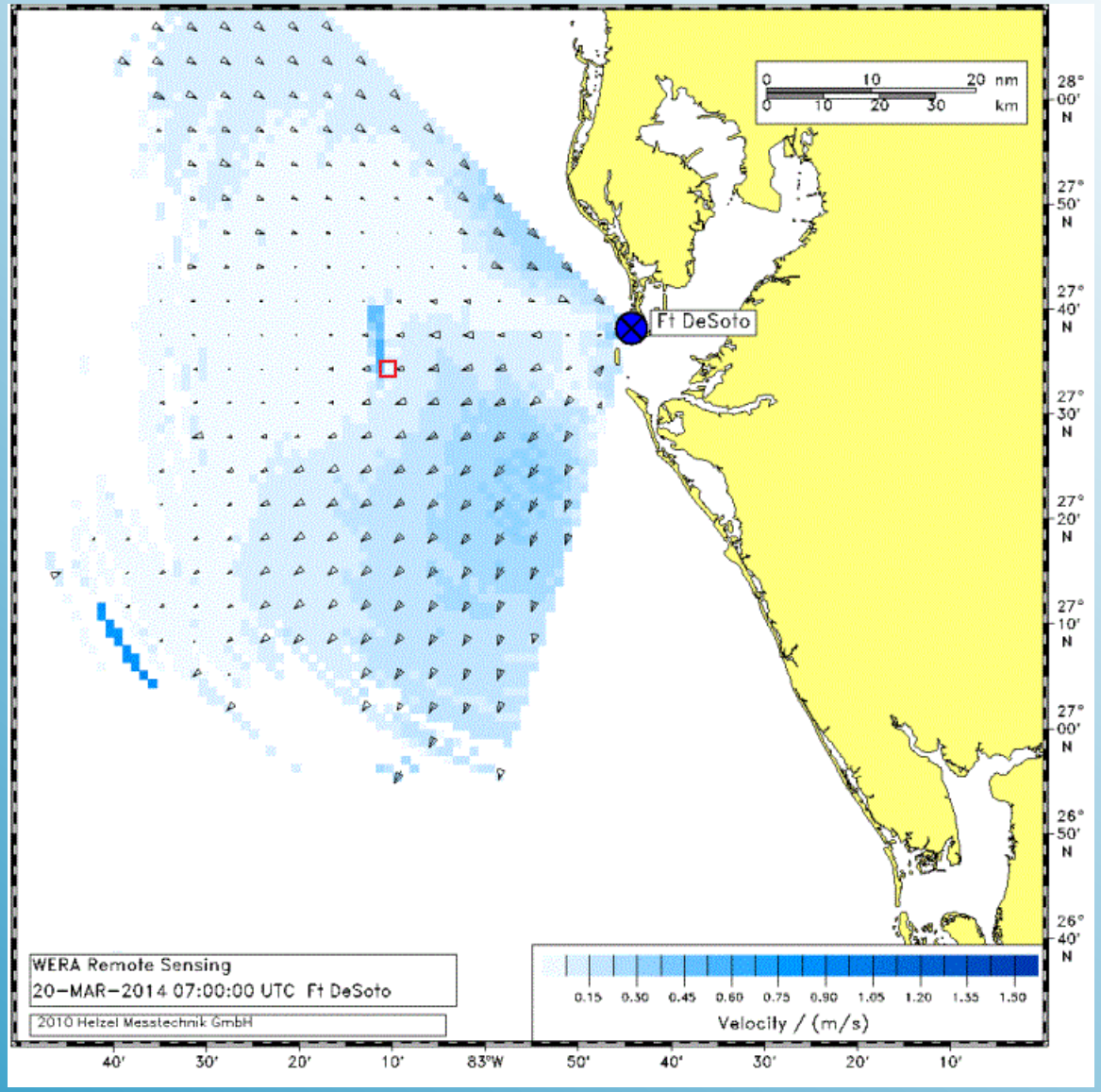


Time series with suspicious data point at end of time series

1. Introduction

Map of radial current velocity from Ft. DeSoto site.

Suspicious data are clearly visible.

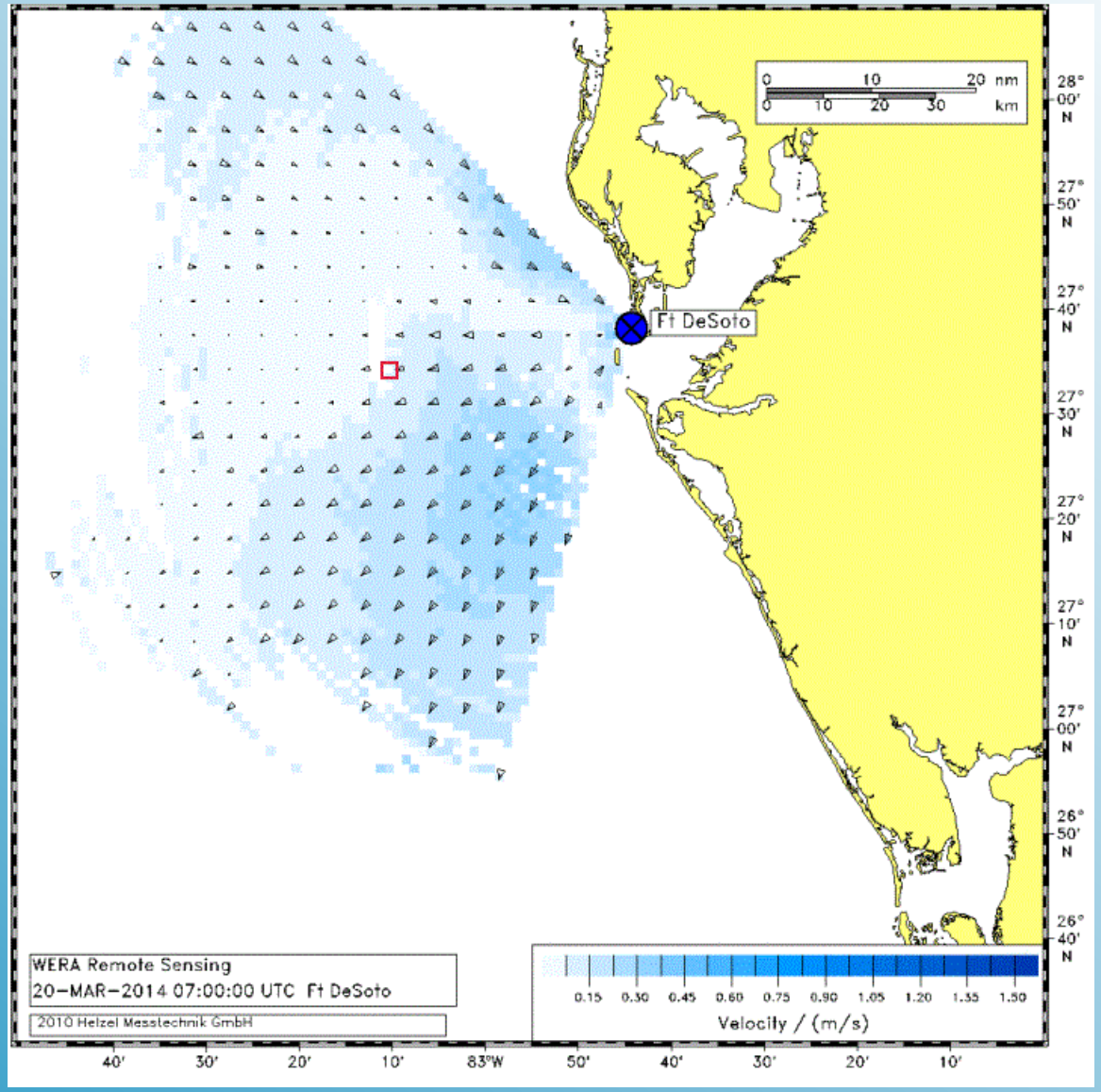


1. Introduction

Cleaning the map from suspicious data in real-time.

NO DATA IS DELETED, JUST MARKED.

THE DATA IS STILL THERE… WE JUST DECIDED NOT TO SHOW IT.



Contents

2. QC Procedure and Outlier Identification

The QC procedure consists of performing a **series of tests** on the measured value **on each grid cell** in the latest radial current map obtained (near real-time).

Before applying the tests, each measured value is assumed to have best quality (QC level of 1).

The tests evaluate the measured data in two different perspectives:

1. **General evaluation of measured values**
2. **Evaluation in time domain.**

2.1 General Evaluation

1st QC-Test:

Verify that the measured value lies within expected range.

For each provided radial current velocity value an accuracy value is available as well.

The accuracy is obtained from a statistical analysis of the samples collected on each grid-cell and considers:

signal / noise, variance & number of samples.

2nd QC-Test:

This accuracy value is itself an indicator of quality of the measurement.

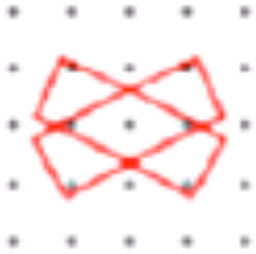
2.2 Evaluation in Time Domain

An **array type** ocean radar provides independent data of surface current for **individual grid cells**.

Nevertheless these data are derived from an area that is different from the size of a Cartesian grid cell.

It is integrated in range and azimuth direction and it is integrated in time, typically for 5 to 20 minutes.

Range:
100 km



Grid cell:
6 km

Integration areas for a pair of 16 antenna WERA systems at about 100 km distance from the radar.

Malcom L. Heron & Daniel P. Atwater, Ocean Sci. J. (2013) 48(1):99-103, KSO, KIOST & Springer 2013

2.2 Evaluation in Time Domain

Due to the described integration effects we can expect slow and smooth data variations at individual gird cells in time. Abrupt changes of the measured values should not occur.

3rd QC-Test:

Verify that the change in radial current velocity with respect to the last measured value lies within defined limits.

2.3 Evaluation in Time Domain

4th QC-Test:

Verify that the new measurement is near an expected value according to a time tendency.

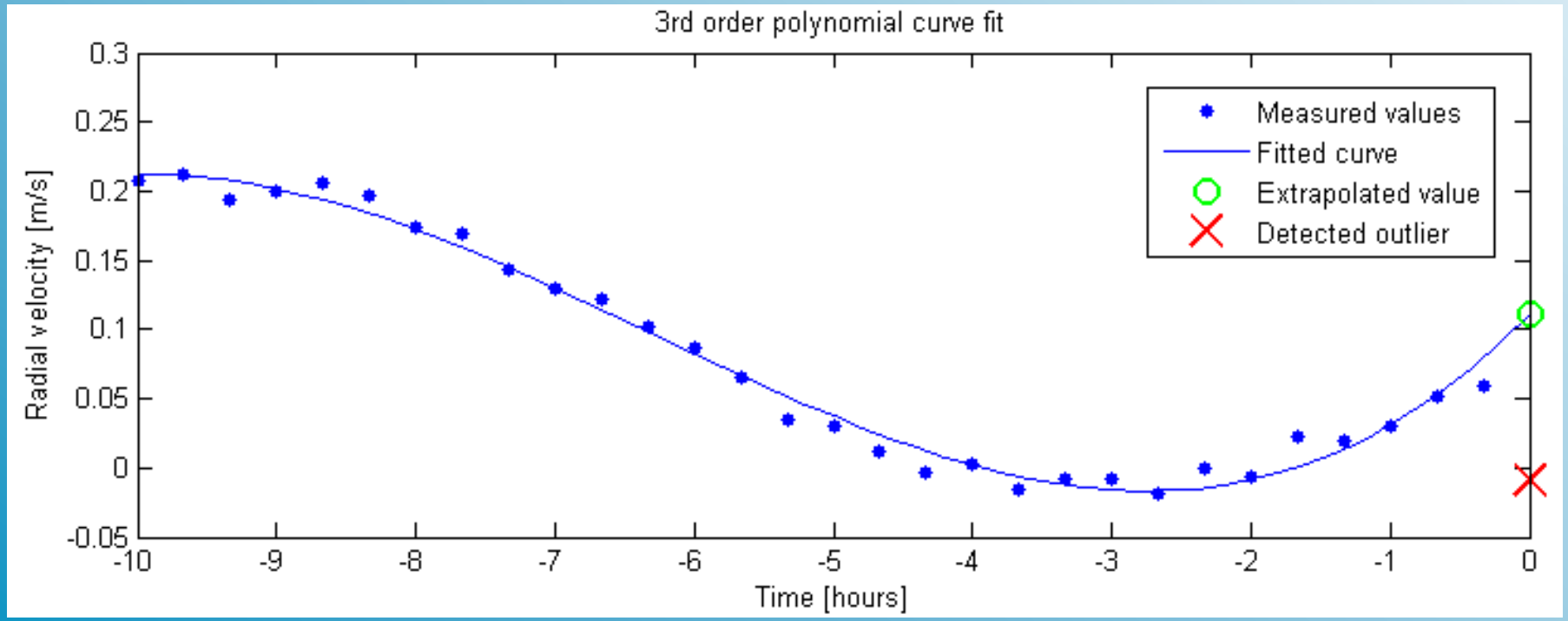
This is done by using the data from a defined period prior to the latest one and fit a 3rd order polynomial curve to these data points.

Estimate (**extrapolate**) a value for the actual measurement and use the **difference** between the extrapolated value and the measured value **as an indicator** of quality.

2.3 Evaluation in Time Domain

4th QC-Test:

Verify that the new measurement is near an expected value according to a time tendency.



2.4 Configurable Parameter

The **thresholds** applied for the QC flagging procedure can be configured according to **site specific** oceanographic conditions

a) Limits of expected current velocities

b) Limits of accepted accuracy values

c) Max. change of current velocity per hour

d) Length of time series to be used for curve fit

e) Minimum number of measurements to use curve fit

f) Max. difference between measured & expected value

Contents

3. Case of Study

A pair of WERA HF radar systems at Fort DeSoto and Venice, operated by University of South Florida, USA

- 12.275 – 13.2 MHz with 12 receive (Rx) antennas
- Measurement range: 120 km (max.)
- Integration time of 15 min for each data set (3 meas/hr using frequency adaptation – 'listen before talk').
- Angular field of view: 120°
- Evaluated period: May 2013 to January 2014

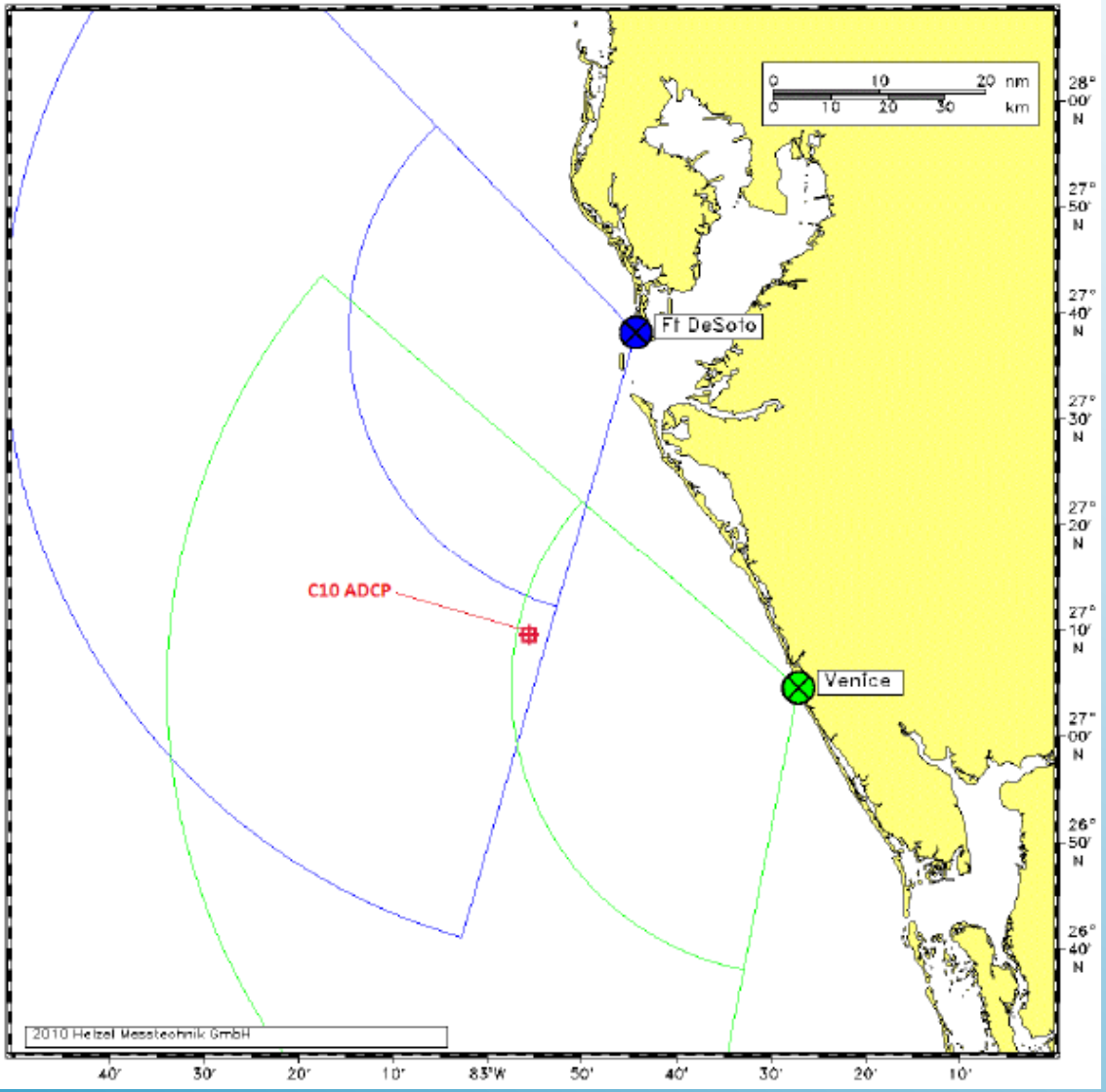
The systems are part of the real-time Coastal Ocean Monitoring Prediction System (COMPS) for the West Florida Shelf region.

3. Case of Study

Site Geometry:

As ground truth an ADCP was used.

The position of this ADCP is not optimal because it is located at the boundary of the angular field of view of the Ft. DeSoto station.



3. Case of Study

Parameters used for Case of Study:

Parameter	Value
Minimum expected current velocity	-0.45 m/s
Maximum expected current velocity	0.45 m/s
1st accuracy threshold	0.025 m/s
2nd accuracy threshold	0.07 m/s
Maximum change of velocity	0.35 m/s·hr
Amount of hours to look in the past	10
Minimum number of measurements	25
Maximum consecutive missing data points	2
Maximum difference between expected value and measured value	0.1 m/s

Contents

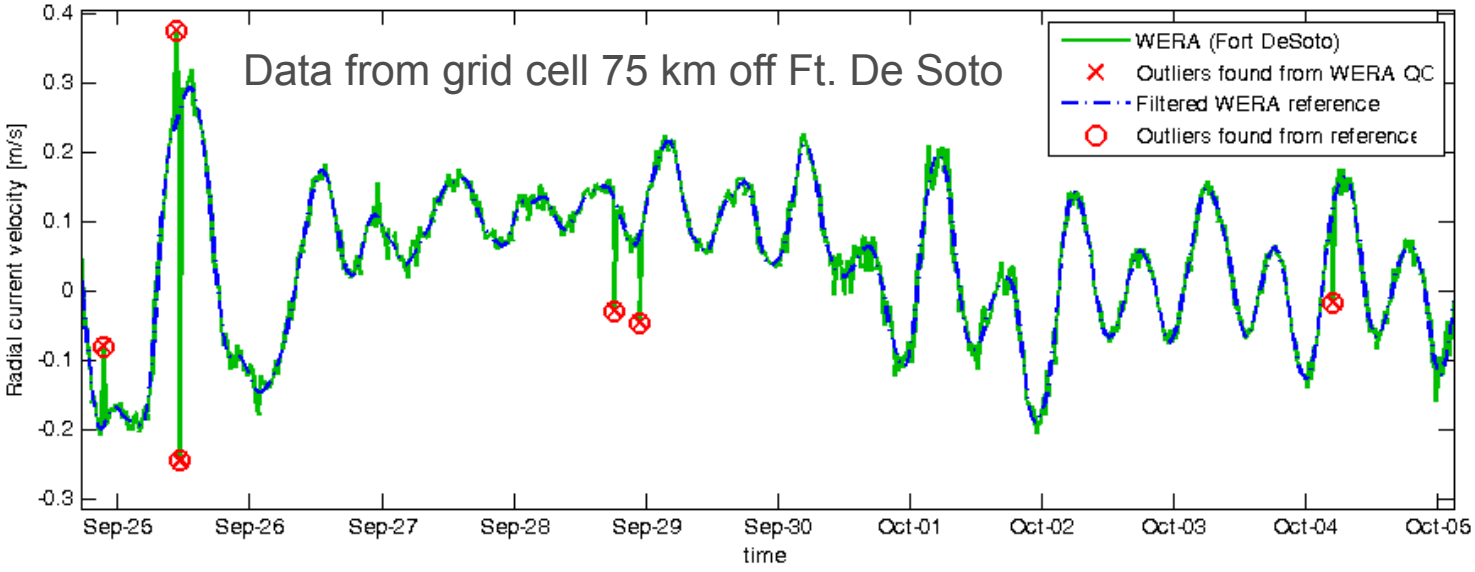
4.1 Evaluation of QC Procedure

- Validation using filtered data as reference:
  - Low pass filtered (60 μHz).
  - 9 months data stream.
  - Analyzed data from 4 ranges at bore sight (30 km to 100 km) for each station.
- Validation using ADCP data as reference:
  - ~3 months data stream.
  - Only data from Venice station.

All data points with a difference of more than 0.1 m/s to the reference line are defined as outliers.

4.2 Results using Ft DeSoto Filtered Ref.

Distance from shore	30 km	50 km	75 km	100 km
Available measurements	18525	18444	17539	14997
Points used for analysis	18500	18429	17481	14759
Confirmed outlier in %	86 %	71 %	71 %	84 %
QC outlier / ref. outlier	24 / 28	15 / 21	29 / 41	104/124



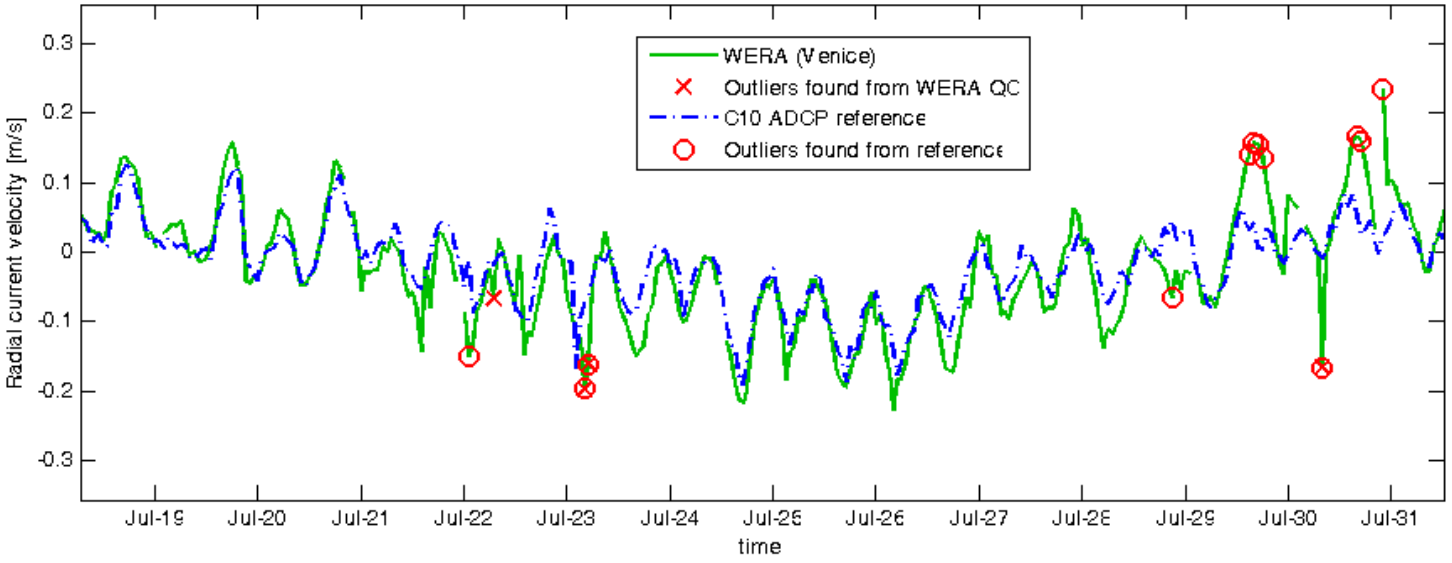
4.2 Results using Venice Filtered Ref.

Distance from shore	30 km	50 km	75 km	100 km
Available measurements	19155	18564	16234	11091
Points used for analysis	19155	18564	16127	7046
Confirmed outlier in %	100 %	72 %	77 %	63 %
QC outlier / ref. outlier	5 / 5	13 / 18	30 / 39	45/72

- High percentage of confirmed outlier identification.
- However, QC also marks measurements as outliers, when they aren't.
- It is always a trade-off, may still be further optimized.

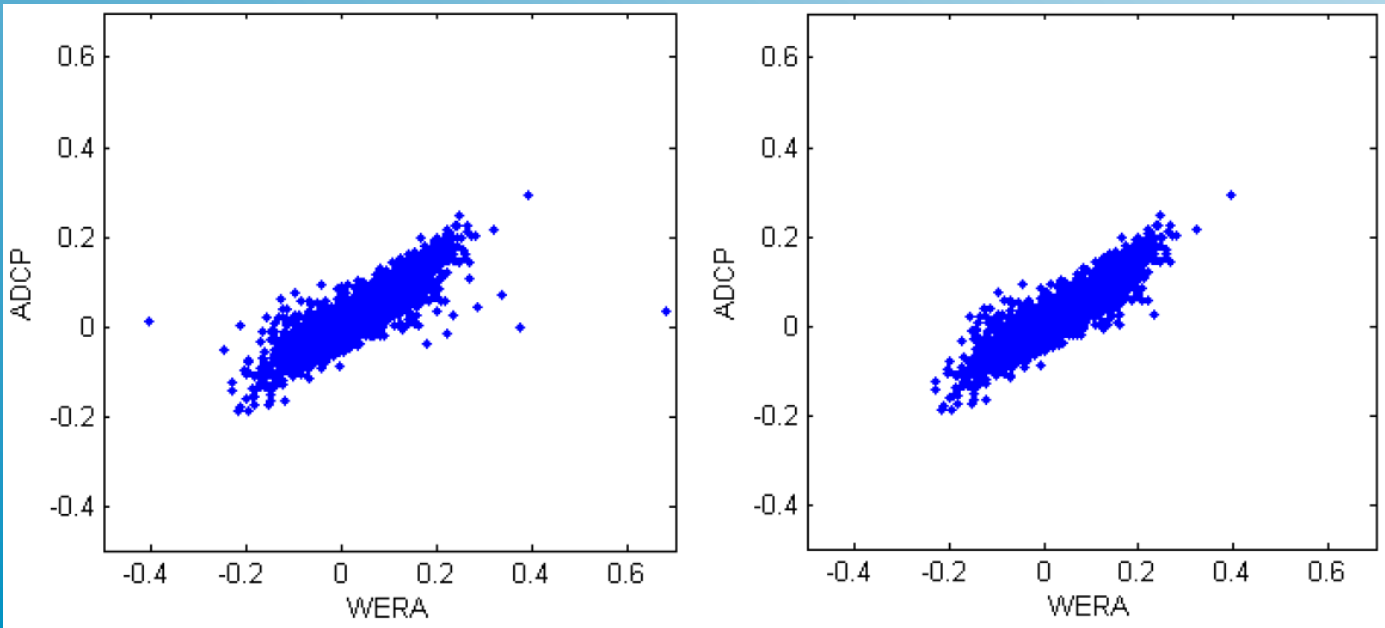
4.3 Results using ADCP

Distance from shore / angle from bore sight	48 km / +30°
Available measurements from ADCP	2470
Points used for analysis (1 point / hour)	2316
Confirmed outlier in % WERA QC outlier / reference outlier	21 % 17 / 81



4.4 Results in Relation to ADCP

- ADCP top bin is 4m vs 0.9 m from WERA
- Different accuracies
- Using 0.17 m/s as difference threshold gives 77% confirmed ID, at expenses of 64% false ID.



Correlation coefficient:

0.87 before QC

0.9 after QC.

Contents

5. Conclusions

- The described QC procedure appears to be a very helpful tool in removing the majority of the outliers in real-time.
- In general, the WERA QC procedure has to be tuned to the specific local conditions of the system for optimal results.
- The optimal setting of the QC procedure parameters is important to obtain the best trade-off between confirmed outlier identification and false outlier identification.
- This method is readily available to be installed on all array type WERA systems.

Contents

6. Similar Methodology for Wave Data

- Applied on combined level (includes direction evaluation).
- No accuracy values evaluated.
- 1st and 2nd order polynomial extrapolation (configurable).
- Calculation of coefficient of determination (R^2).
- Available to be integrated already on array-type WERA.

Contents

7. Future Tasks

- More validation results (also for Wave).
- Different parameters for different areas of the ocean.
- In addition to that it would be useful to include spatial analysis as one QC test in near real-time. An off-line version was already introduced by Arnstein Prytz from the University of Townsville, Australia.

Acknowledgement

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The success of the seagoing operations is largely due to the technical expertise of J. Law and J. Donovan, and D. Mayer assisted with the ADCP data analysis. This is CPR Contribution # 33.

Thank you for your attention !