Mid-Atlantic HF Radar Update

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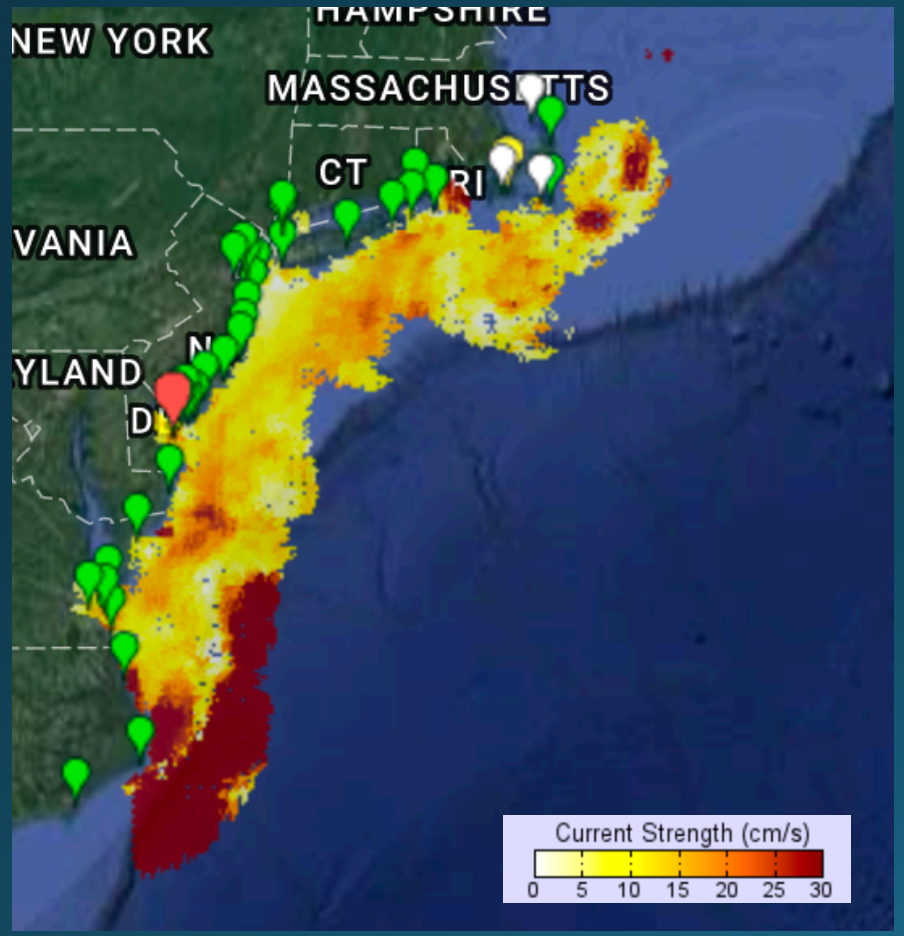
Old Dominion University
MABPOM 2017

MARACOOS
Ocean Information for a Changing World

IOOS
INTEGRATED OCEAN OBSERVING SYSTEM

SECOORA
Southeast Coastal Ocean Observing Regional Association

Mid-Atlantic HFR Network

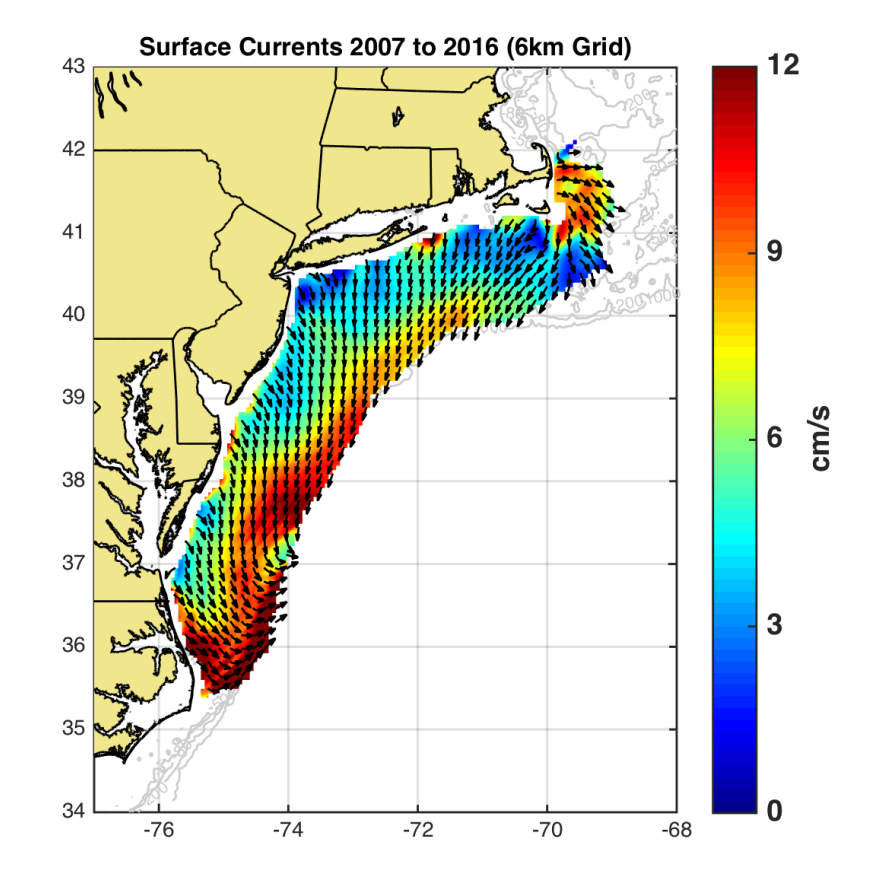


- 41 High Frequency Radar Stations
  - 17 long range
  - 9 standard range
  - 15 high resolution
- Operated by
  - University of Massachusetts Dartmouth
  - University of Connecticut
  - Woods Hole Oceanographic Institution
  - Rutgers University
  - Old Dominion University
  - University of North Carolina/ Coastal Studies Institute
- 10+ years of coverage extending across the region

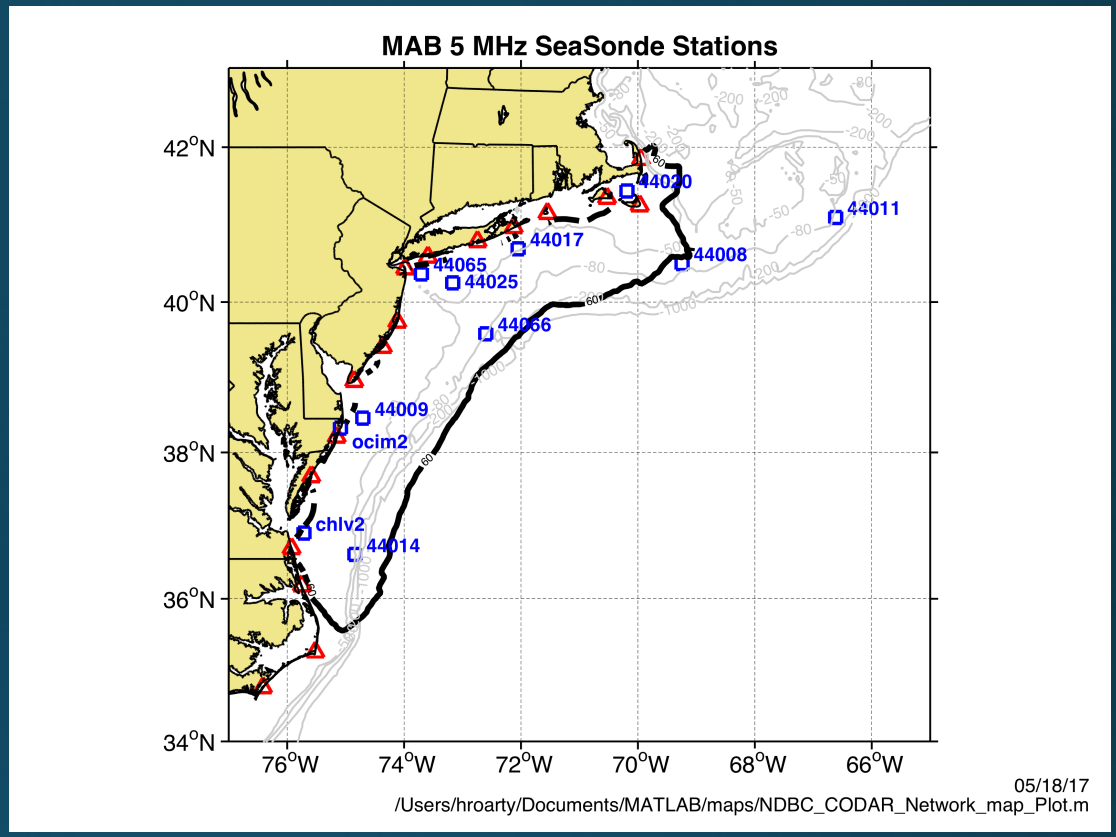
25 hour average of surface currents centered on Sep 11 2017 17:00 UTC
http://cordc.ucsd.edu/projects/mapping/maps/

OUTLINE

- Mid-Atlantic Bight 10 year dataset analysis (2007-2016)
- Coast Guard drifter experiment
- Operations
- Real-time QC efforts



Average surface flow (2007-2016) measured by the long range HF radar network.



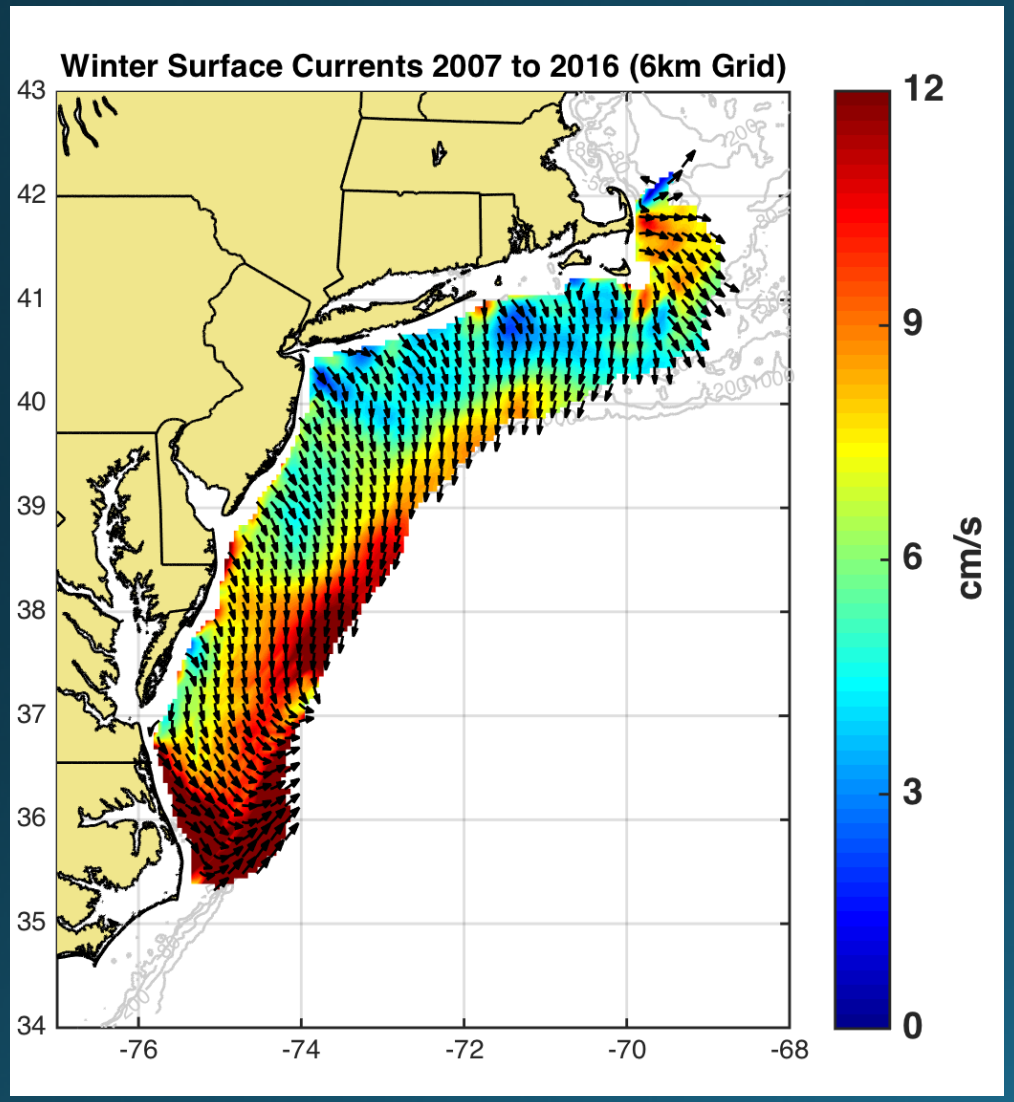
Locations of 5Mhz HF radar stations (red triangles) and NDBC buoys (blue squares). The black line delineates area of 60% radar data coverage.

Ten Year Dataset Analysis led by Rutgers University

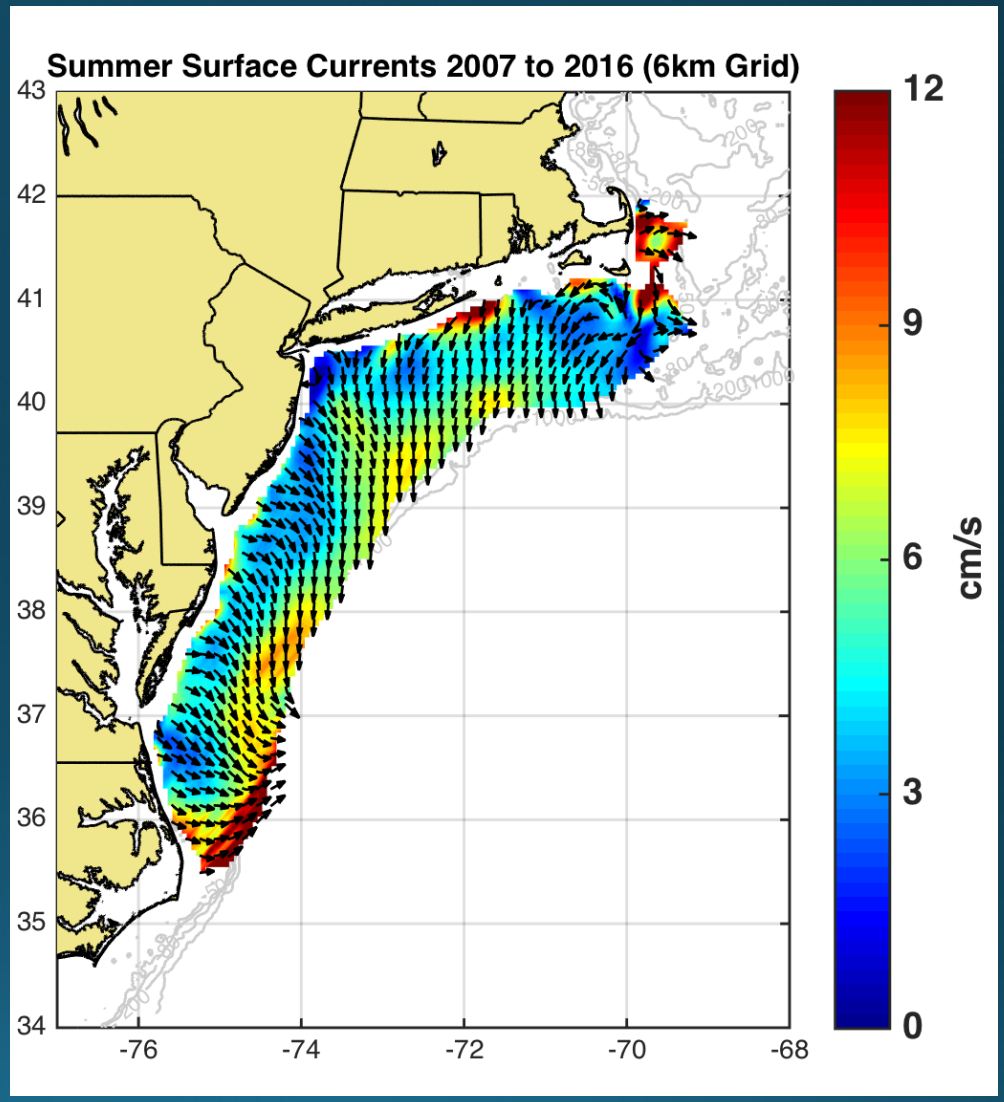
RUTGERS
Coastal Ocean Observation Lab

Figures provided by Rutgers.

WINTER



SUMMER



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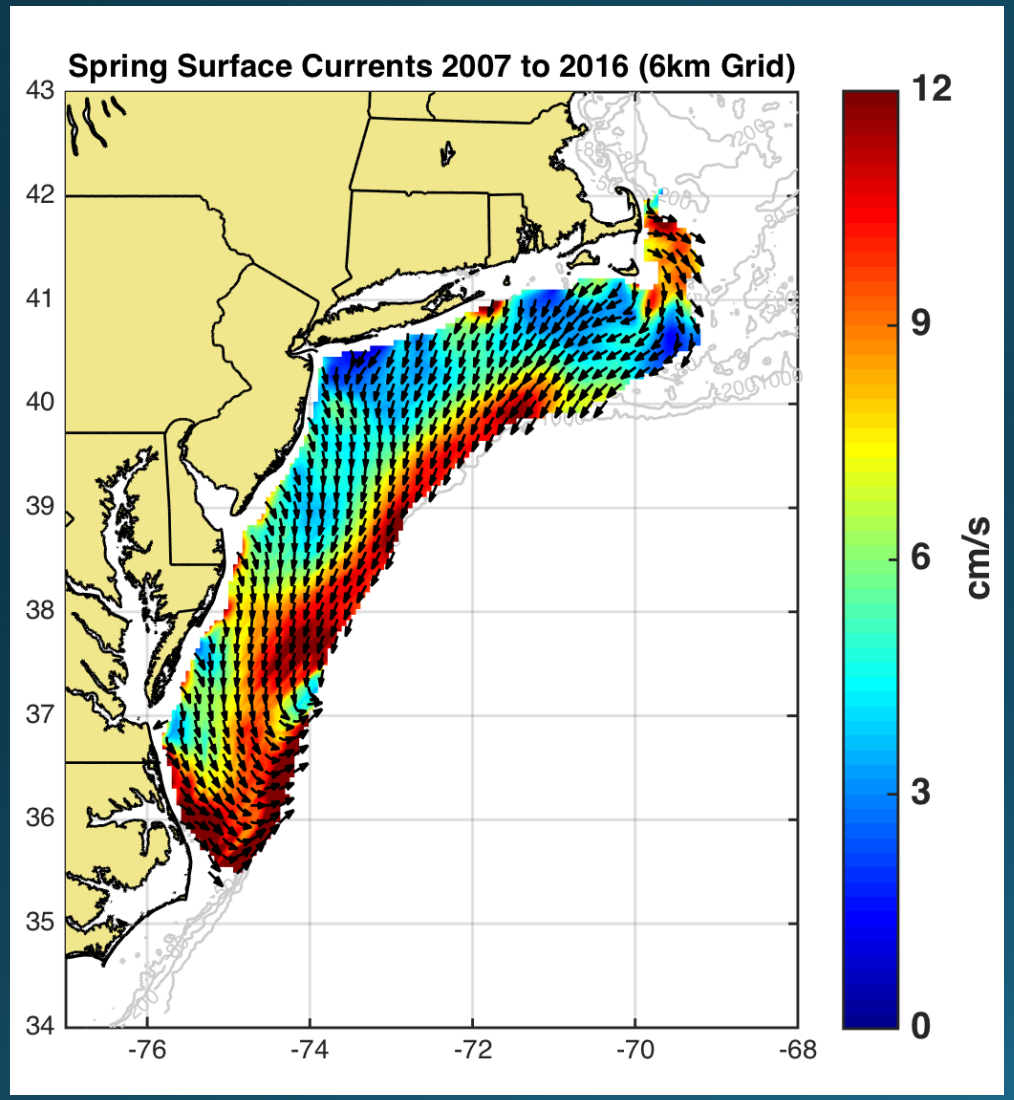
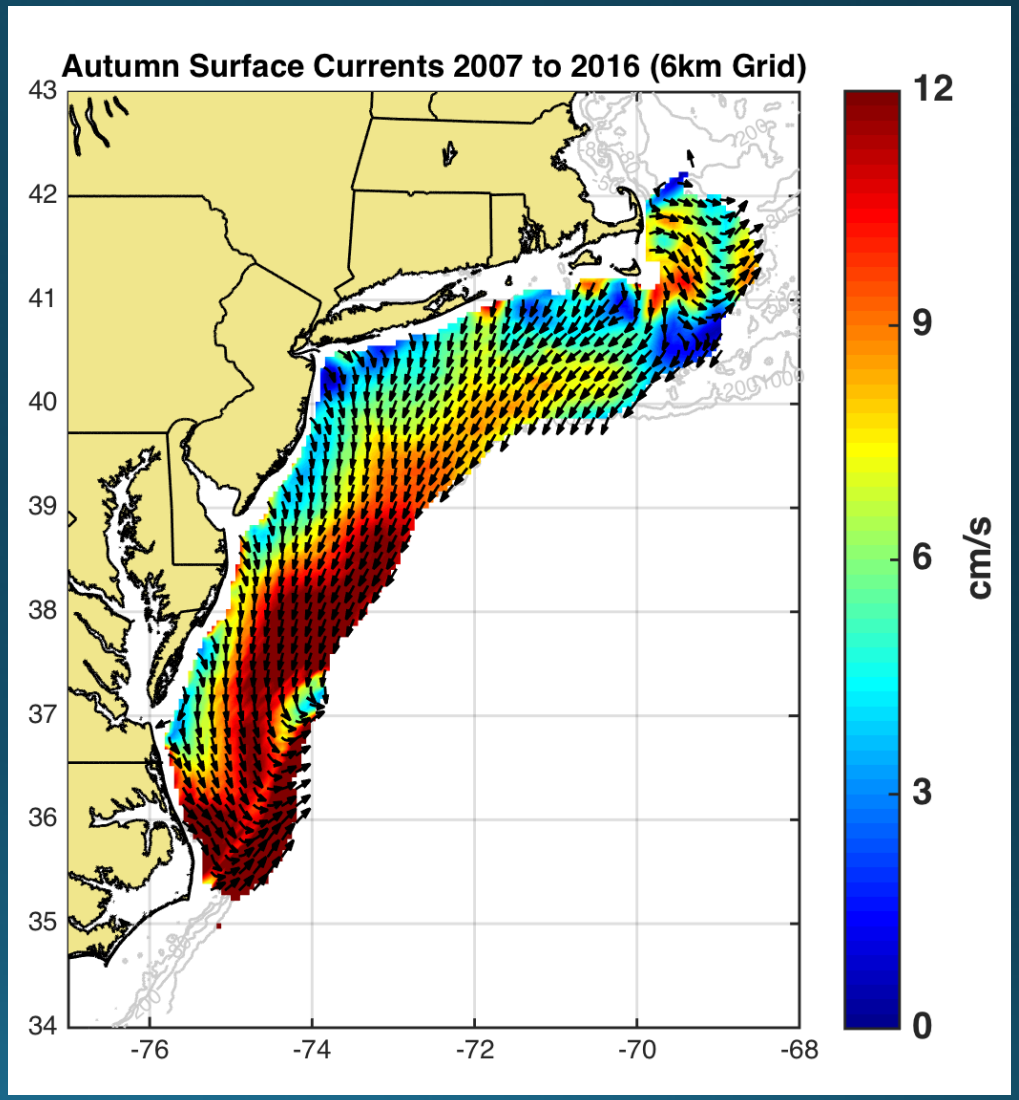
Seasonal mean surface flow (2007-2016). Figures provided by Rutgers.

SPRING



FALL



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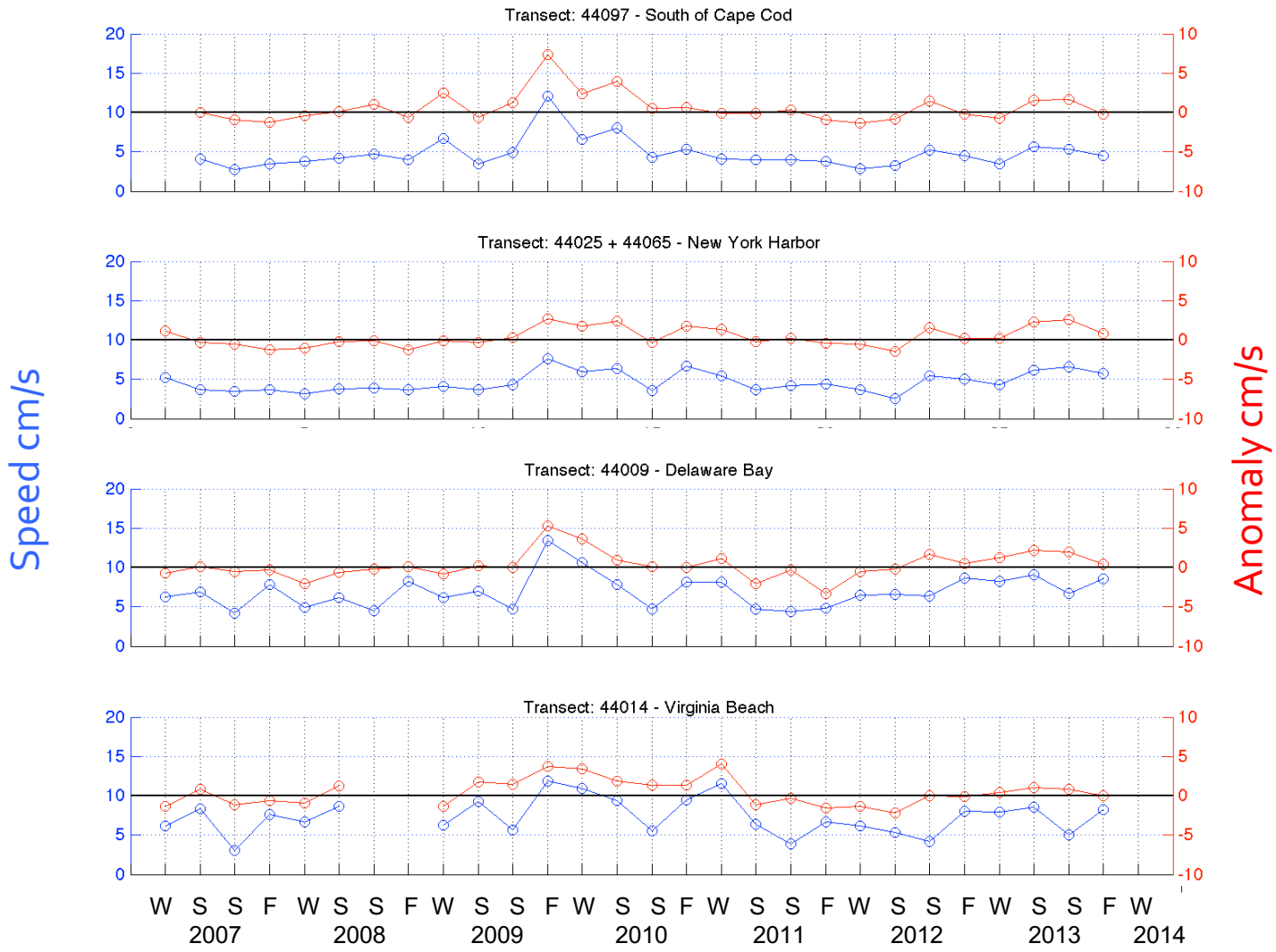
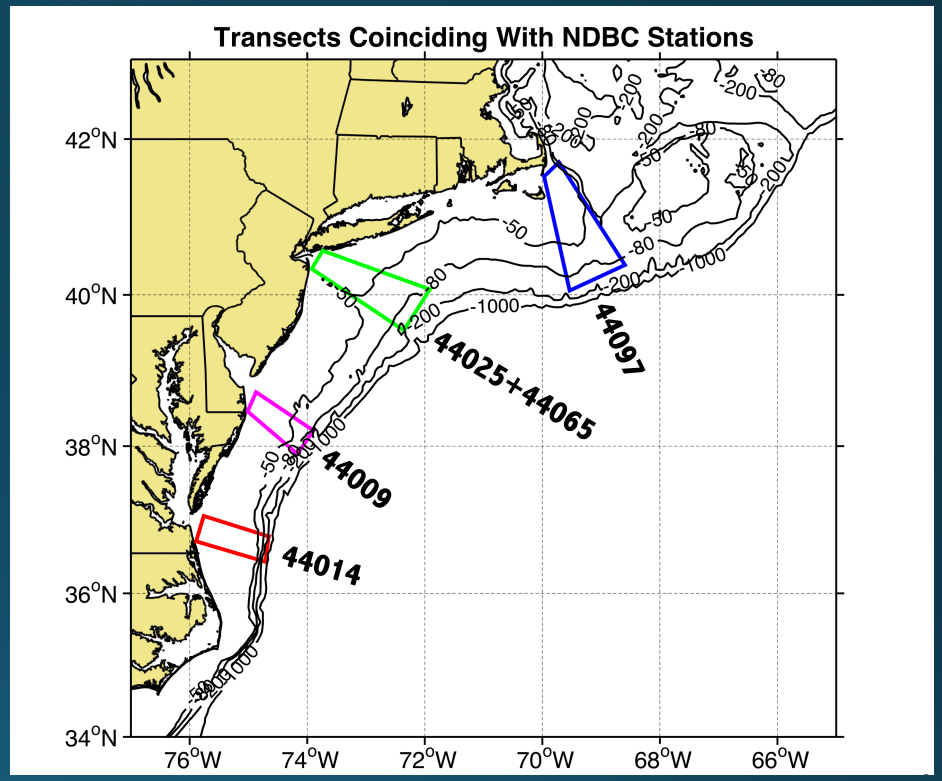
Seasonal mean surface flow (2007-2016). Figures provided by Rutgers.





Inter-annual variability of seasonal average surface currents. Figures provided by Rutgers.

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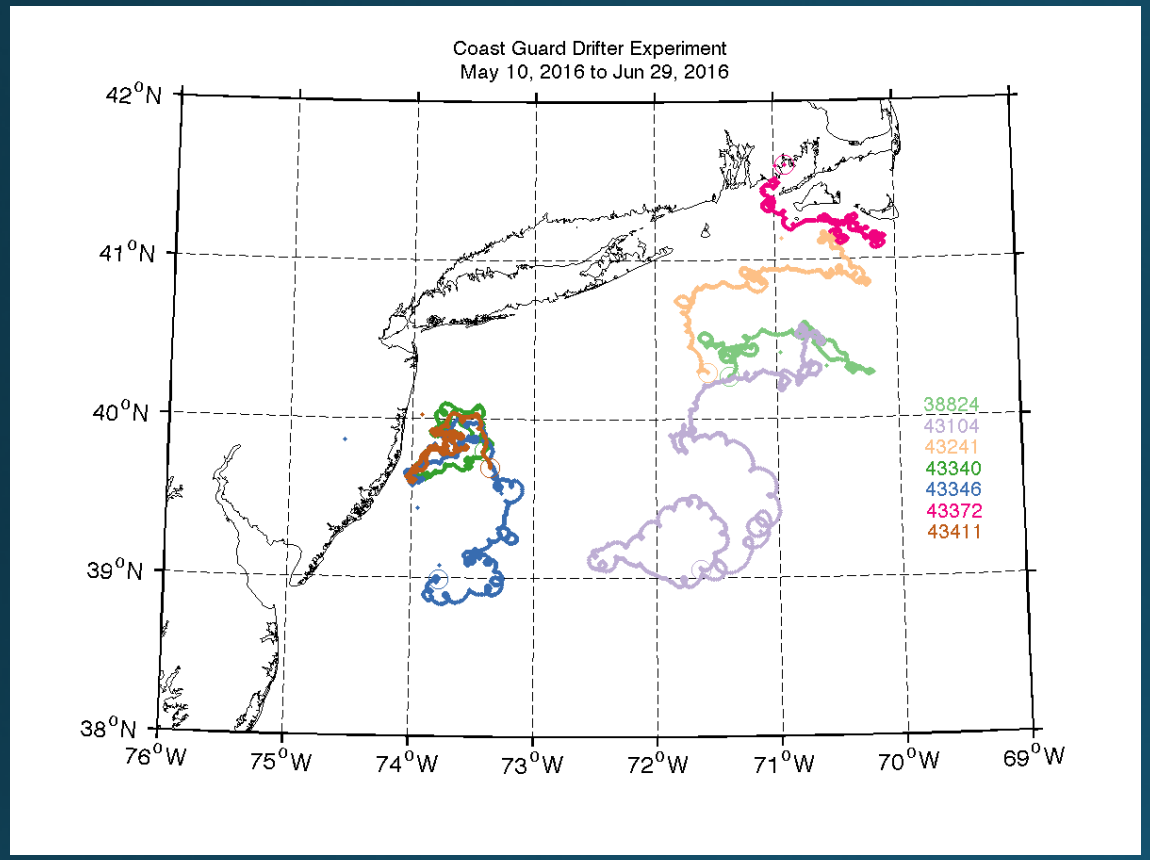
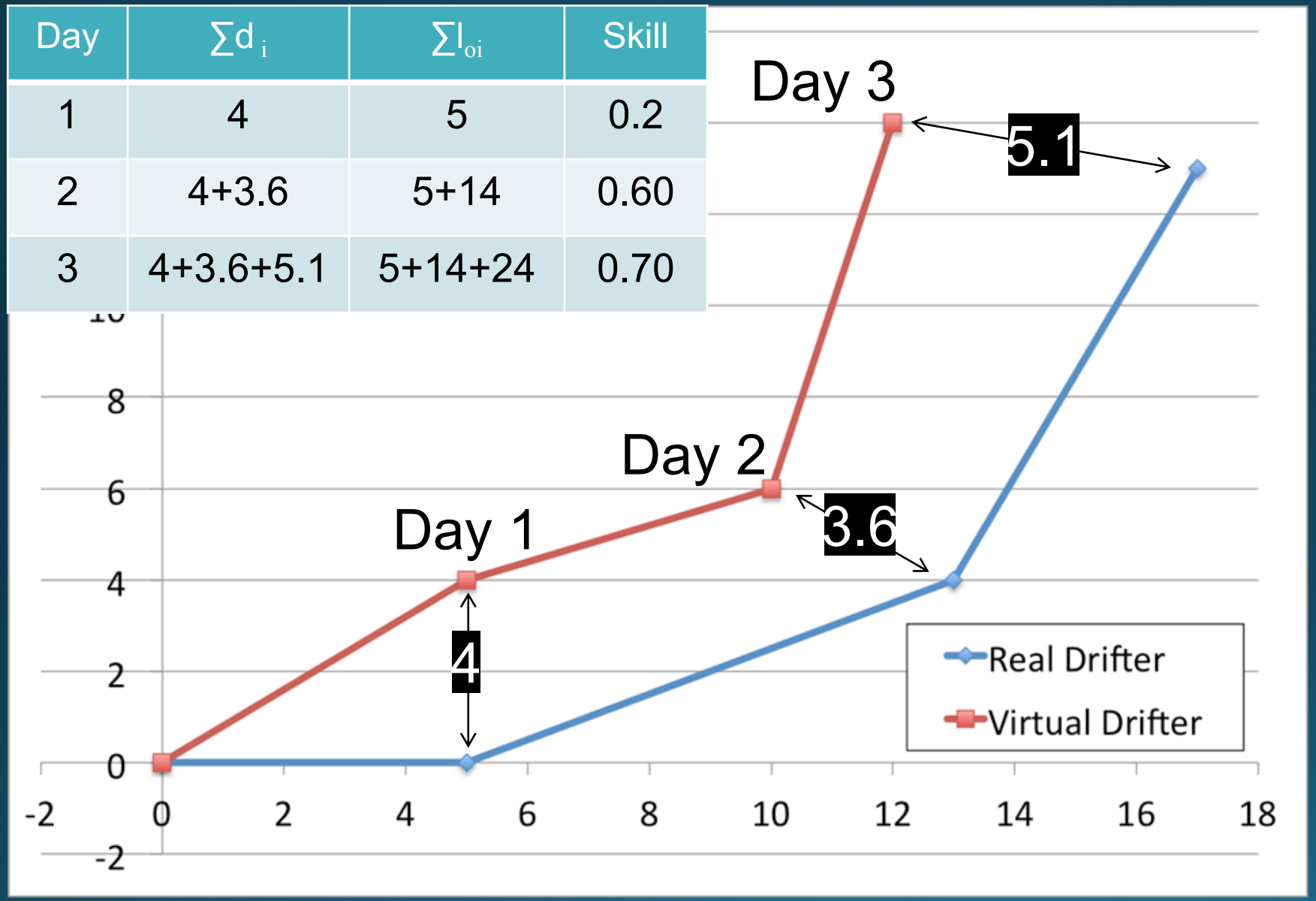
Coastal Ocean Observation Lab



May 10 to July 10 2016

2016 Coast Guard Drifter Experiment

Day	$\sum d_i$	$\sum l_{oi}$	Skill
1	4	5	0.2
2	4+3.6	5+14	0.60
3	4+3.6+5.1	5+14+24	0.70



$$s = \sum_{i=1}^{N} d_i \Big/ \sum_{i=1}^{N} l_{oi}$$

$$\begin{cases} 1 - \frac{s}{n}, & (s \le n) \\ 0, & (s > n) \end{cases}$$

Cumulative Skill Score (Liu and Weisberg, 2011)

Skill Scores:

48 hour forecasts calculated every 24 hours

#	Buoy Number	Description	5MHz	13MHz	HYCOM (NoAtl)
1	43241	MVCO 30 m isobath	0.65	-	0.05
2	43372	MVCO 30 m isobath	0.44	-	0.20
3	38824	MVCO 70 m isobath	0.62	-	0.07
4	43104	MVCO 70 m isobath	0.45	-	0.04
5	43340	NJ	0.65	0.61	0.12
6	43346	NJ	0.65	0.69	0.12
7	43411	NJ	0.69	0.67	0.09
		Average	**0.59**	**0.66**	**0.10**

EDS Skill Scores:

6 hour forecasts calculated every hour

Buoy Number	*HFRadar**	*Espresso~*	*HYCOM (Navy)*	*HYCOM (NoAtl)*	*STPS*
43241	0.42	0.39	0.20	0.16	0.19
43372	0.33	0.32	0.17	0.15	0.22
38824	0.36	0.36	0.16	0.17	0.11
43104	0.23	0.24	0.21	0.11	0.15
43340	0.38	0.24	0.26	0.17	0.16
43346	0.41	0.12	0.26	0.19	0.16
43411	0.37	0.11	0.24	0.11	0.19
Average	**0.36**	**0.25**	**0.21**	**0.15**	**0.17**

* Mid-Atlantic HF Radar Product
~ less than 10 track hours for each buoy

Operations

HFR Web Interface for Operators

HF Radar Operator Website

Log Out Outages Site Checks Site Management My Account Admin

Report an Outage Review Past Outages

Current Reported Outages

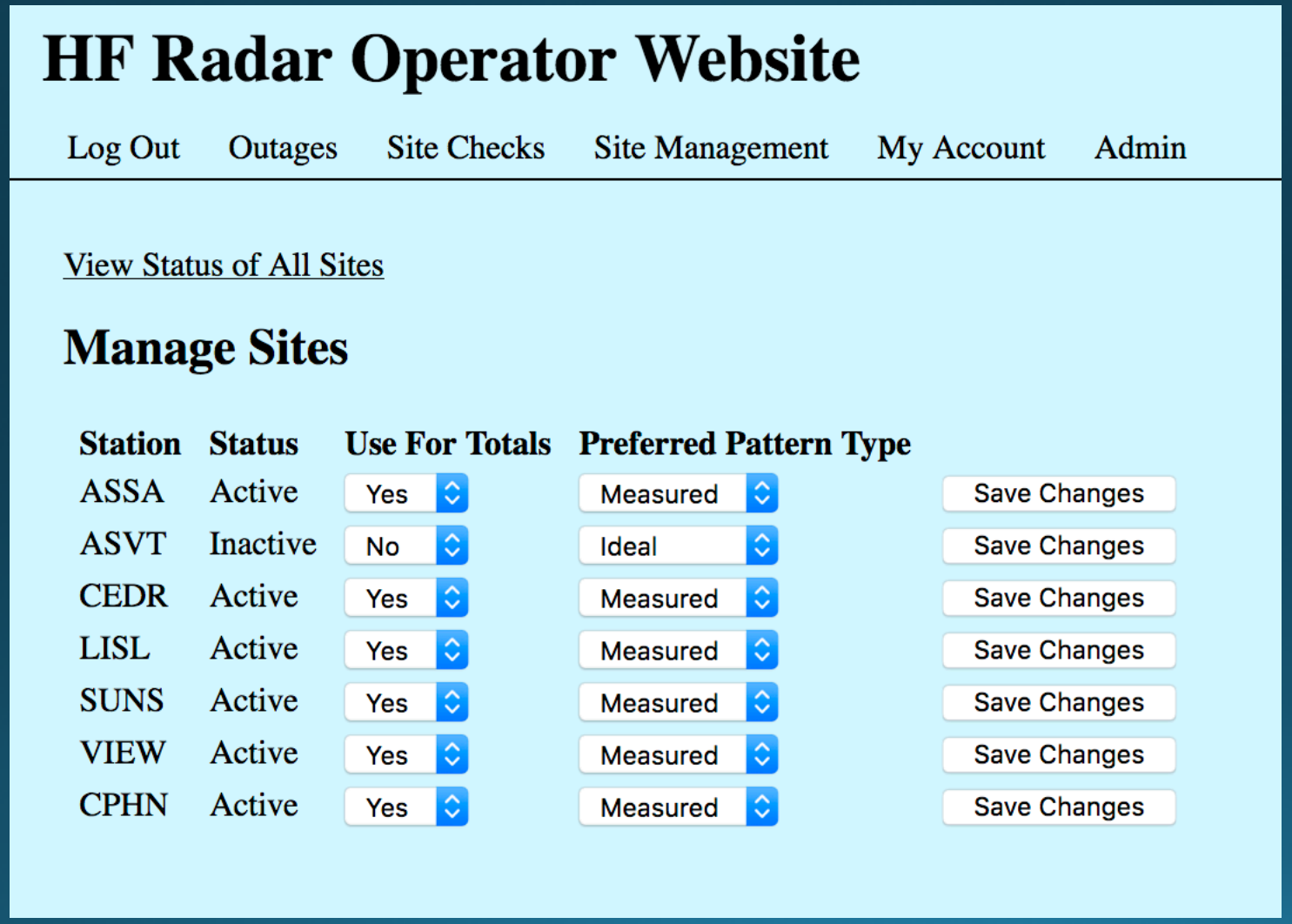
Site	Reason	Notes	Last Radial Time	Estimated Repair Date	Last Updated	Edit/Clear
HLPN	unknown,communications	likely another communications problem	2017-08-24 05:00:00	2017-09-20	2017-09-15 12:03:35	
MVCO	power	Maintenance at MVCO.	2017-09-06 18:00:00	2017-09-15	2017-09-15 13:20:16	
MABO	unknown,power	hurricane Maria	2017-09-06 18:00:00	2017-10-31	2017-09-21 13:39:57	
PYFC	unknown,power	hurricane Maria	2017-09-18 17:00:00	2017-10-31	2017-09-21 13:40:16	
CDDO	unknown,power	hurricane Maria	2017-09-18 14:00:00	2017-10-31	2017-09-21 13:40:33	
FURA	unknown,power	hurricane Maria	2017-09-19 13:00:00	2017-10-31	2017-09-21 13:40:48	
FARO	unknown,power	hurricane Maria	2017-09-18 12:00:00	2017-10-31	2017-09-21 13:41:01	

Outage Analysis

- 157 reports
- Power and Communications failures most common (37)
- Hardware caused most downtime

Code	Description	Count	Length (days)
100	**Hardware**	**29**	**725.1**
110	Transmitter	3	20.5
120	Receiver	2	23.9
130	Transmit Antenna	1	212.7
140	Receive or Combination Antenna	5	249.8
150	Cable	8	72.8
160	Enclosure/Climate Control	2	29
170	GPS	6	48.7
199	Other	2	67.7
200	**Computer/Software**	**25**	**350.8**
210	Computer Hardware Failure	2	21.4
220	Operating System Crash	4	18.9
230	Software Program/Processing Failure	2	12.3
240	Communication to Receiver/Transmitter Lost	13	247.3
250	Disk Space Full	2	38.7
299	Other	2	12.2
300	**Communications**	**37**	**292.2**
310	Service Provider Outage	5	31.5
320	Hardware Failure (Modem,Router, etc)	6	65.1
330	Local Network Configuration	18	174.9
340	National Network Portal or Node	1	4.2
399	Other	7	16.5
400	**Site Operation and Maintenance**	**18**	**387.5**
410	Routine/Preventative Maintenance	6	262.8
420	Incorrect User-Defined Operational Settings	3	10.7
430	Incorrect Hardware/Cable Configuration	0	0
440	Radio Frequency	0	0
499	Other	9	114
500	**Power**	**37**	**251.4**
510	Service Provider Outage	13	113.5
520	Hardware Failure (UPS, Power Switch,...)	4	21.8
530	Circuit or Ground Fault Trip	12	83.9
599	Other	8	32.2
999	**Unknown**	**11**	**48.8**

HFR Web Interface for Operators



Real-time Quality Control

Overview of QC Efforts

- Radial Metric QC Implementation (UNC/CSI)
- Implementation of QARTOD in regional product (Rutgers)
- New Test Studies & Test Thresholds (Rutgers & ODU)

Radial Metric Quality Control

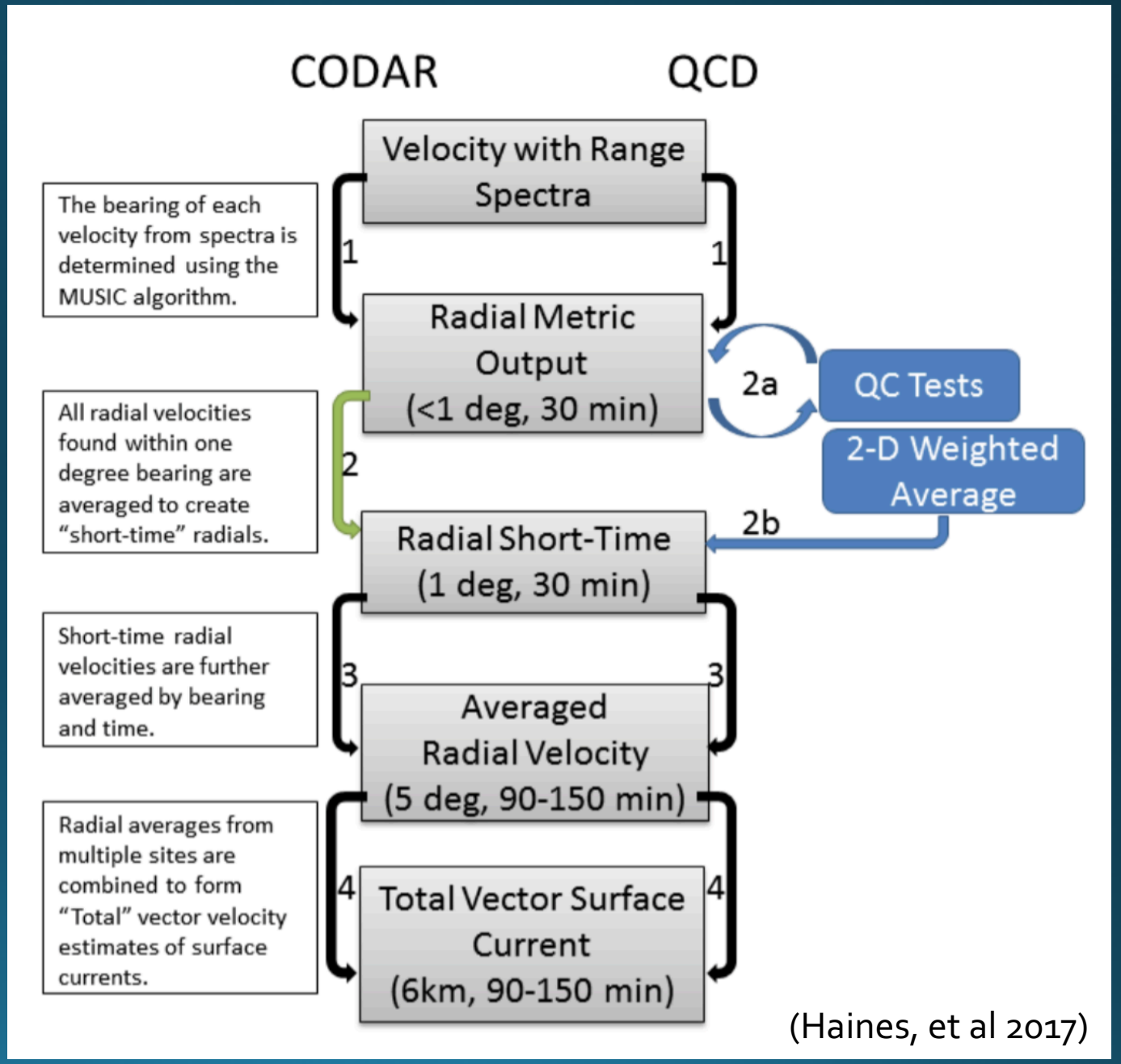
- Haines, S., Seim, H. and M. Muglia 2017: **Implementing Quality Control of High-Frequency Radar Estimates and Application to Gulf Stream Surface Currents**. J. Atmos. Oceanic Technol., doi:10.1175/JTECH-D-16-0203.1

- Kirincich, A. R., T. de Paolo, and E. Terrill, 2012: Improving HF radar estimates of surface currents using signal quality metrics, with application to the MVCO high-resolution radar system. J. Atmos. Oceanic Technol., 29, 1377–1390, doi:10.1175/JTECH-D-11-00160.1.

- QCD now operational in North Carolina CODAR systems!
- Implemented with Python

THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL

Coastal Studies Institute
University of North Carolina



(Haines, et al 2017)

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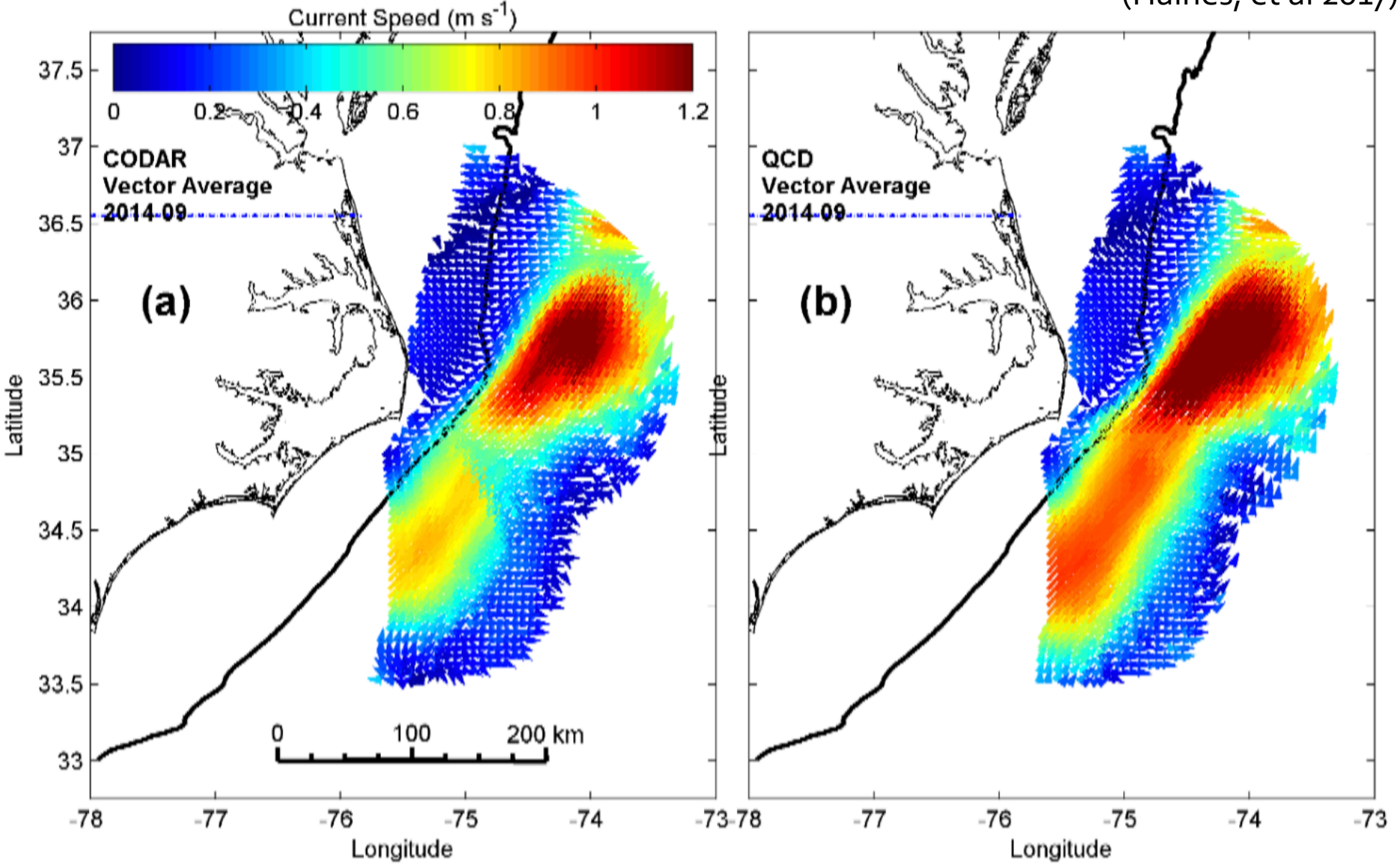
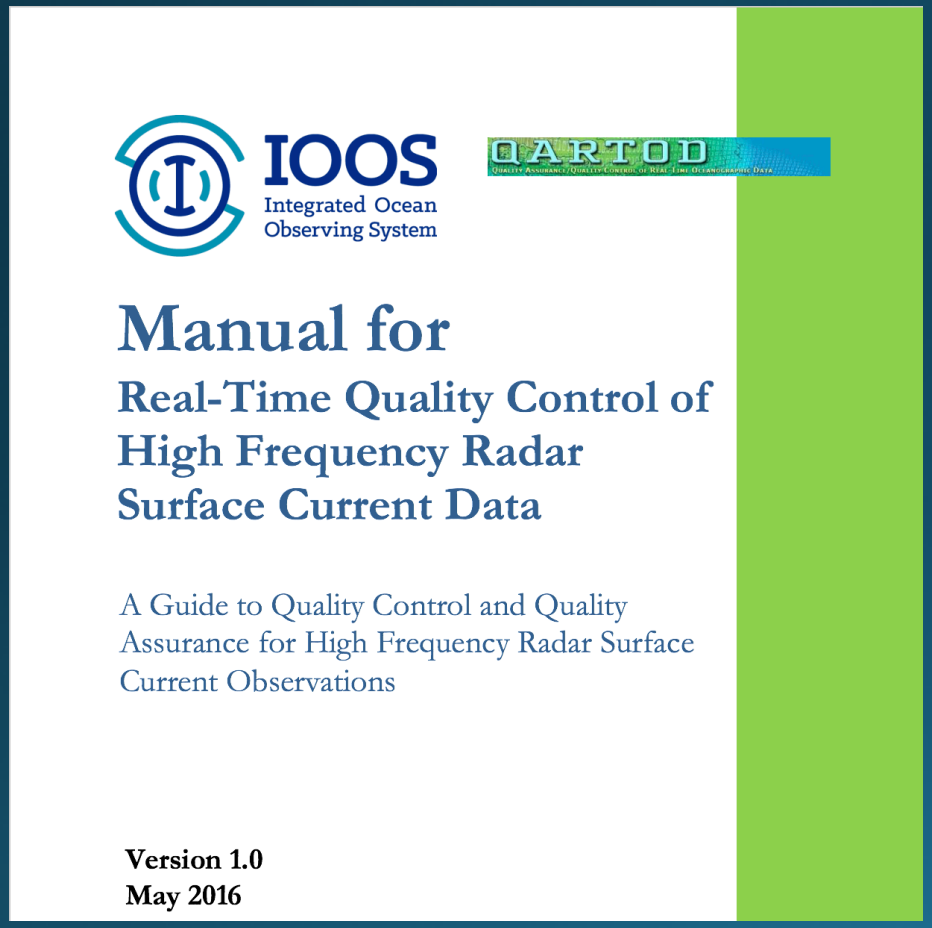
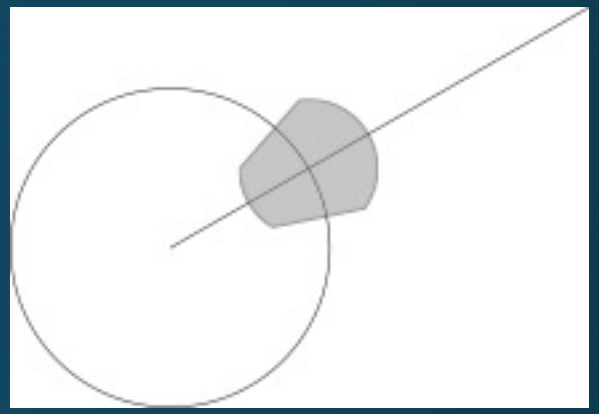


QARTOD Implementation



Group 1 Required	Test 1	Signal-to-Noise Ratio
	Test 6	Syntax
	Test 7	Max Threshold
	Test 8	Valid Location (radial components)
	Test 14	Data Density Threshold*
	Test 15	GDOP Threshold
	Test 16	Max Speed Threshold
Group 2 Strongly Recommended		None.
Group 3 Suggested	Test 2	Cross Spectra Covariance Matrix Eigenvalues
	Test 3	Single and Dual Angle Solution - DOA Metrics (magnitude)*
	Test 4	Single and Dual Angle Solution - DOA Function Widths (3 dB)*
	Test 5	Positive Definiteness of 2×2 Signal Matrix*
	Test 10	Spatial Median Filter* (radial components)
	Test 11	Temporal Gradient
	Test 12	Average Radial Bearing*
	Test 17	Spatial Median Comparison (total vectors)
Group 4 In Development	Test 9	Radial Count*
	Test 13	Synthetic Radial

Spatial Median Test

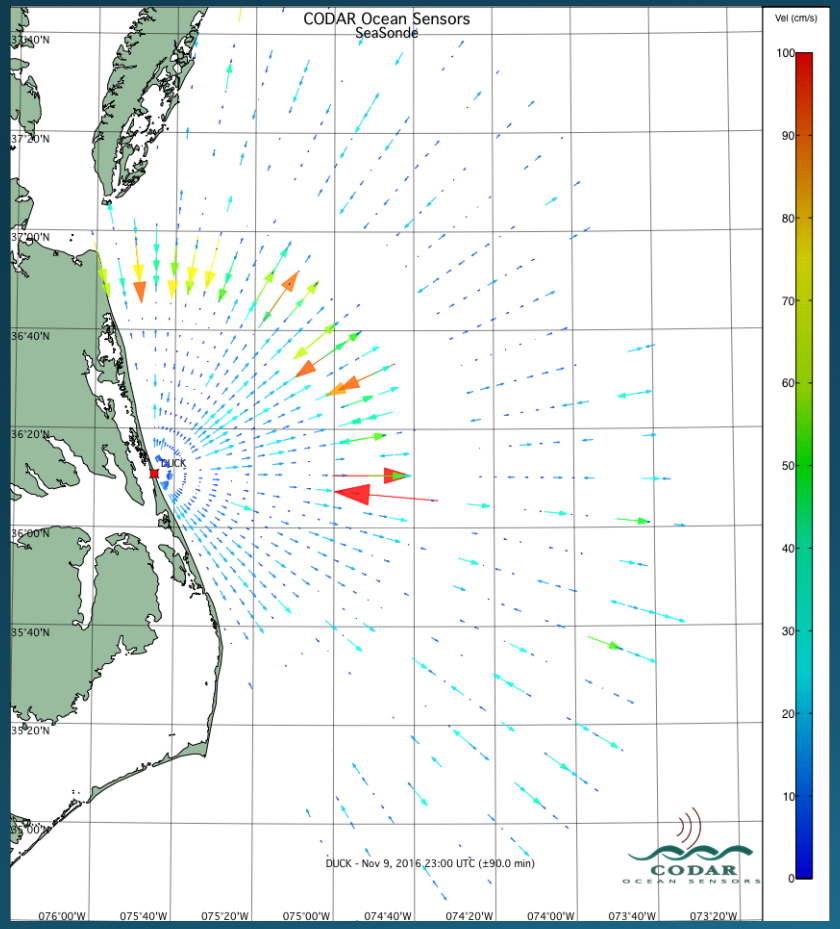


- RCLim = 2.1
- AngLim = 10 degrees
- CurLim = 30 cm/s
- V = source vector velocity
- MV = Median of all velocities in neighboring area

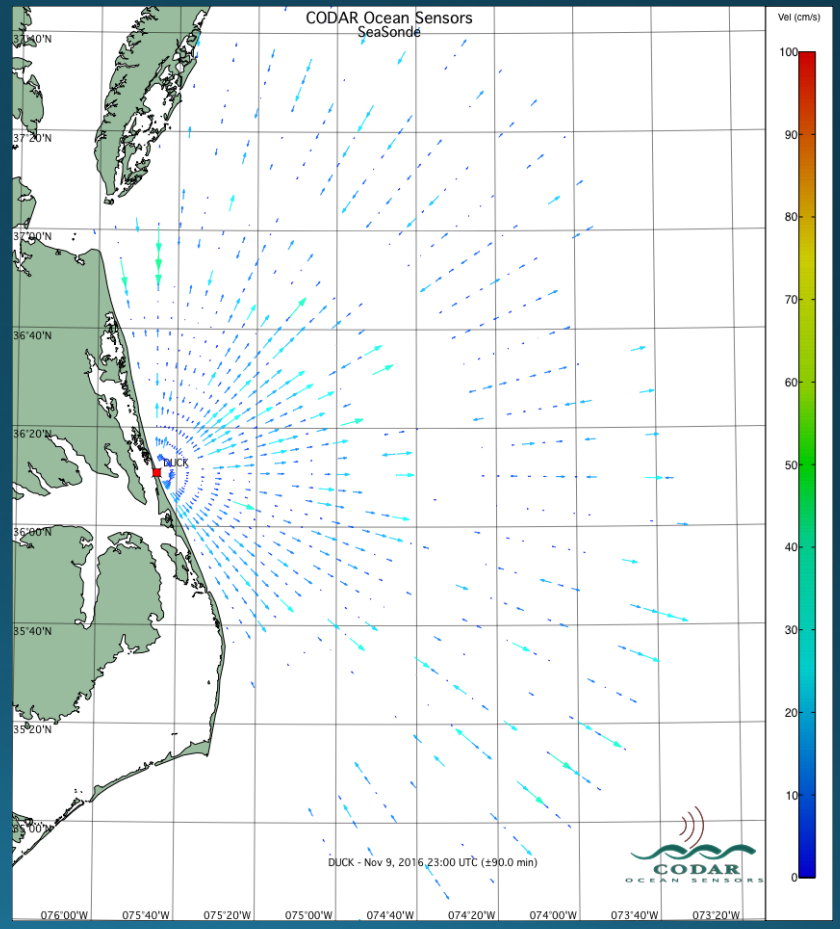
If V – MV > CurLim, the vector is flagged.

Test based on optional filtering in CODAR SeaSonde software.

Spatial Median Test Example



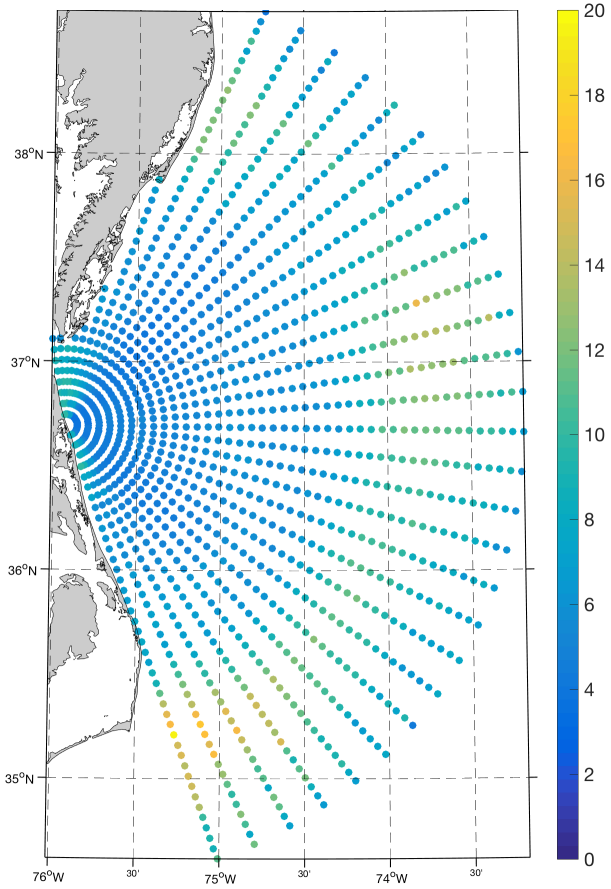
Original LISL radial map.



Map with vectors flagged by the test removed.

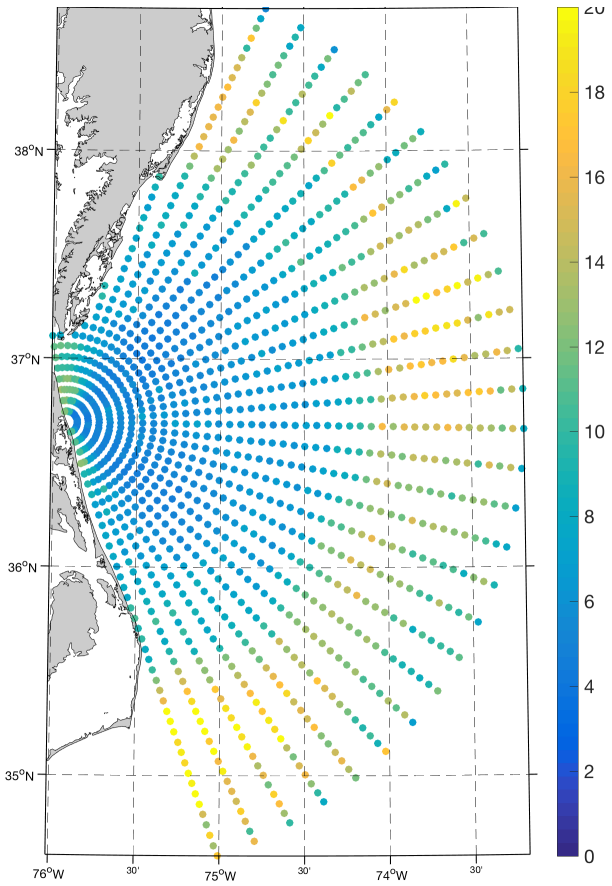
Determining Thresholds: Temporal Gradient Example

Gradient Average



LISL May 10 – July 11 2016

Gradient Standard Deviation



Gridded total vector data is available at these locations:

- http://hfrnet.ucsd.edu/thredds/catalog.html (National product)
- http://tds.marine.rutgers.edu/thredds/cool/codar/cat_totals.html (Rutgers regional product)
- ERDDAP (https://coastwatch.pfeg.noaa.gov/erddap)