# Surface Currents from Ultra-Thin Drifters Compared to HF Radar and Drogued Drifter Measurements

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*Morey, S.L., N. Wienders, D.S. Dukhovskoy, and M.A. Bourassa (2018). Measurement characteristics of near-surface currents from ultra-thin drifters, drogued drifters, and HF radar. Remote Sensing, 10, 1633, doi:10.3390/rs10101633*

*This work was supported by NOAA/CIMAS award NA15OAR4320064 subaward S17-09*

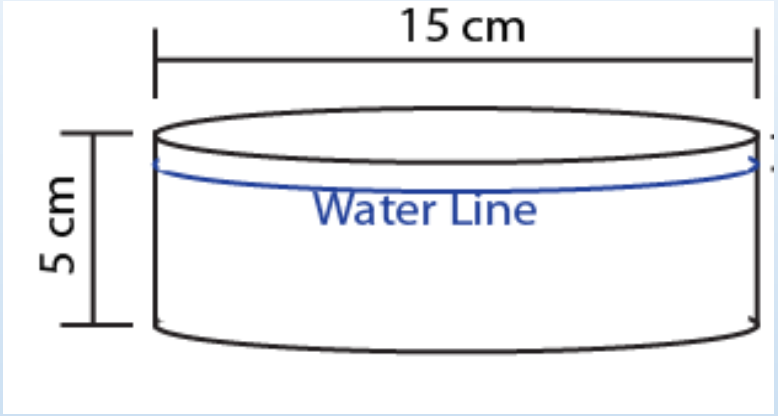
# Characteristics of an “Ideal” Surface Drifter

(*Davis, 1982*)

Objective: A drifter whose motion approximates the mean fluid velocity at its location on the surface.

- Minimum windage
- A good surface follower – high heave frequency and significant damping and/or buoyancy
- Small compared to the scale of the velocity gradients (vertical and horizontal)
- Little tilt with respect to the wave surface

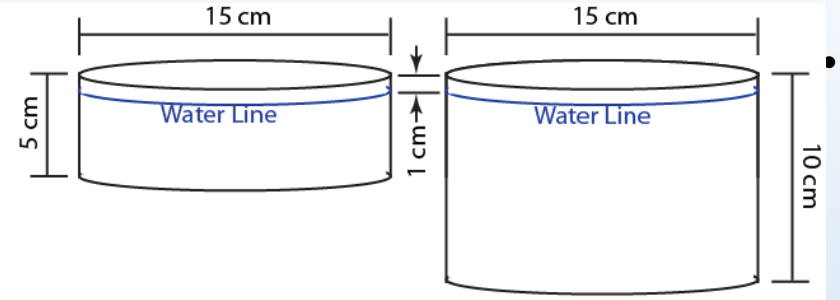
**= A small flat disk**

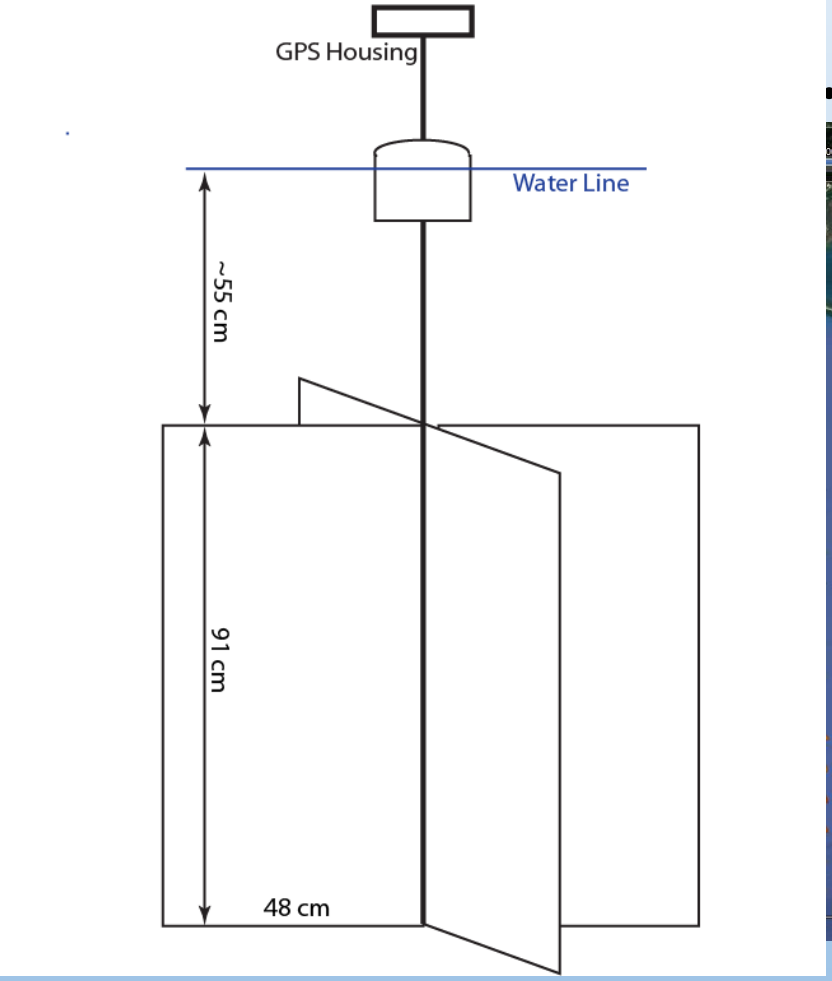



“Stokes Drifter” – A flippable thin disk surface drifter.


*Nicolas Wienders, Florida State University*

# Experiment

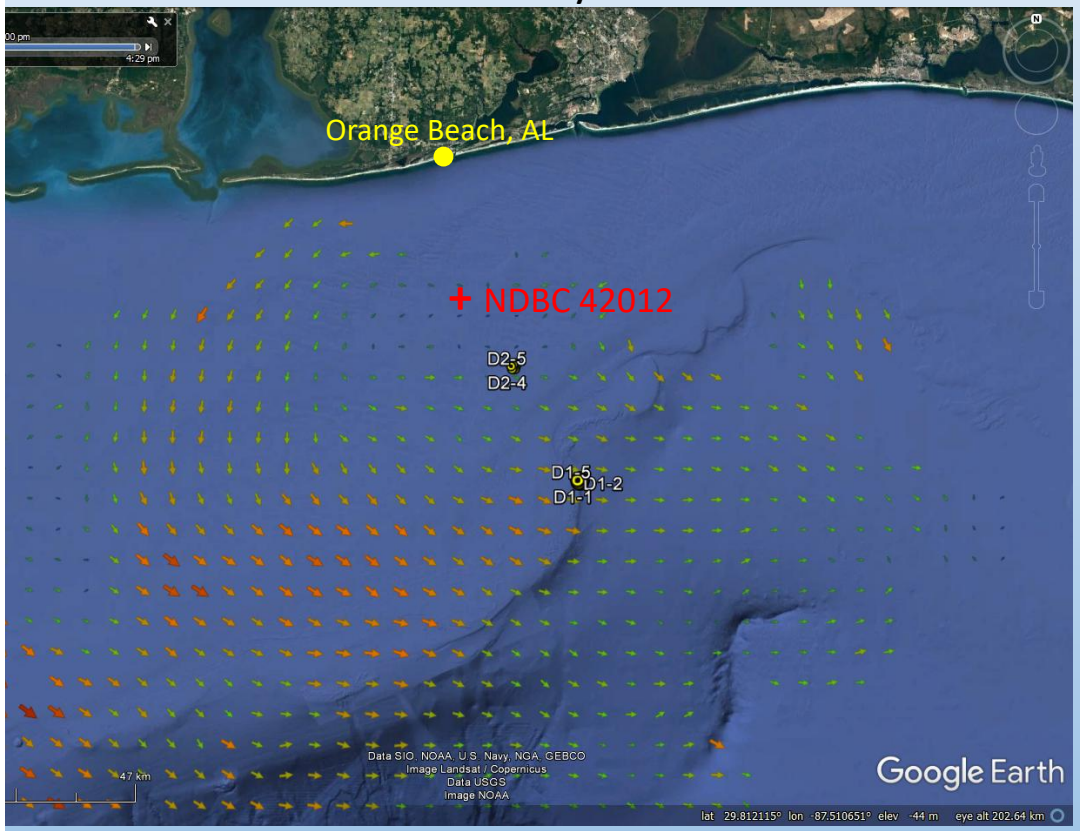



- 30 5-cm drifters
  28 10-cm drifters
  14 CODE-style drifters (drogue at 0.5-1.5m depth)
  Drift Cards

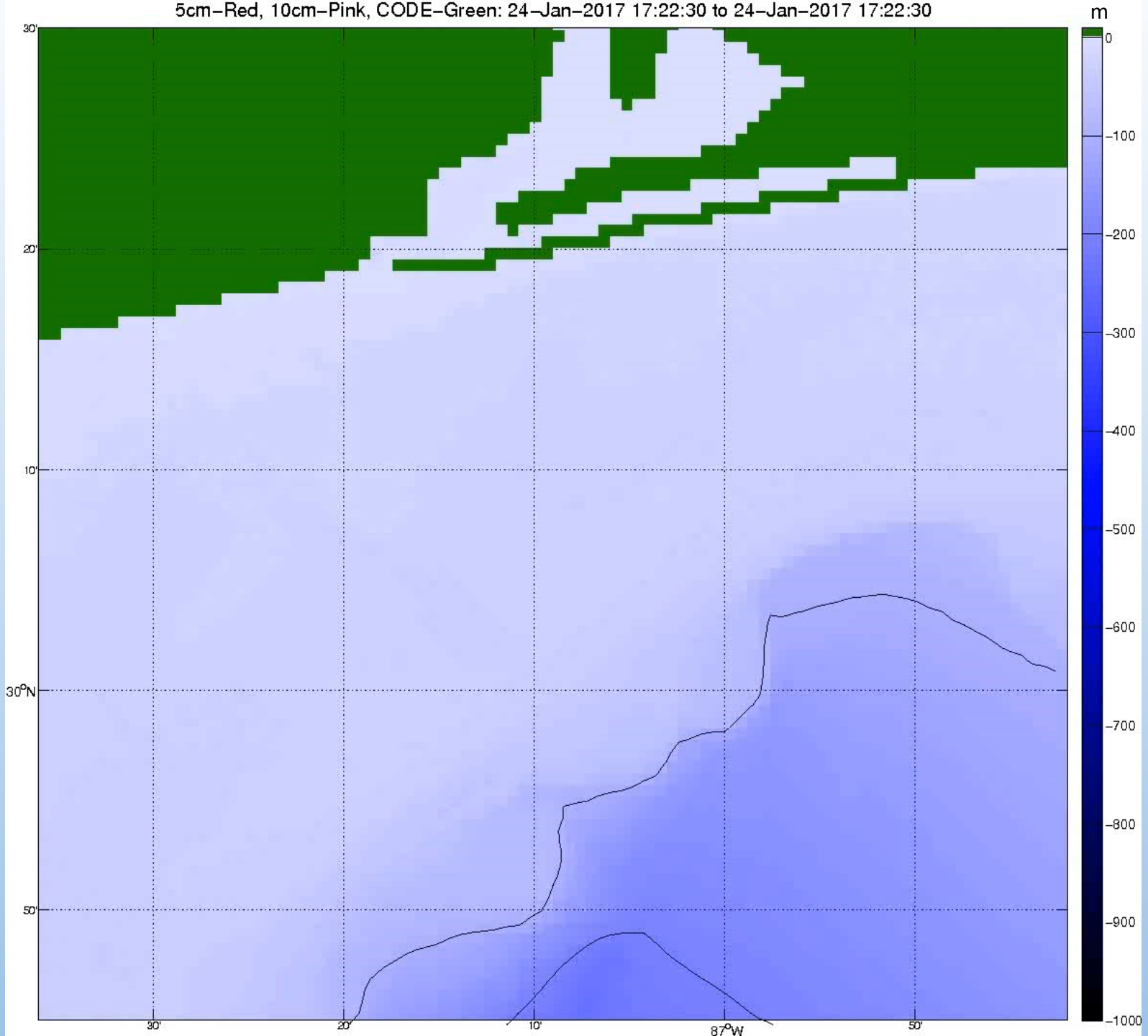
- Deployed 24 January 2017 off Orange Beach, AL

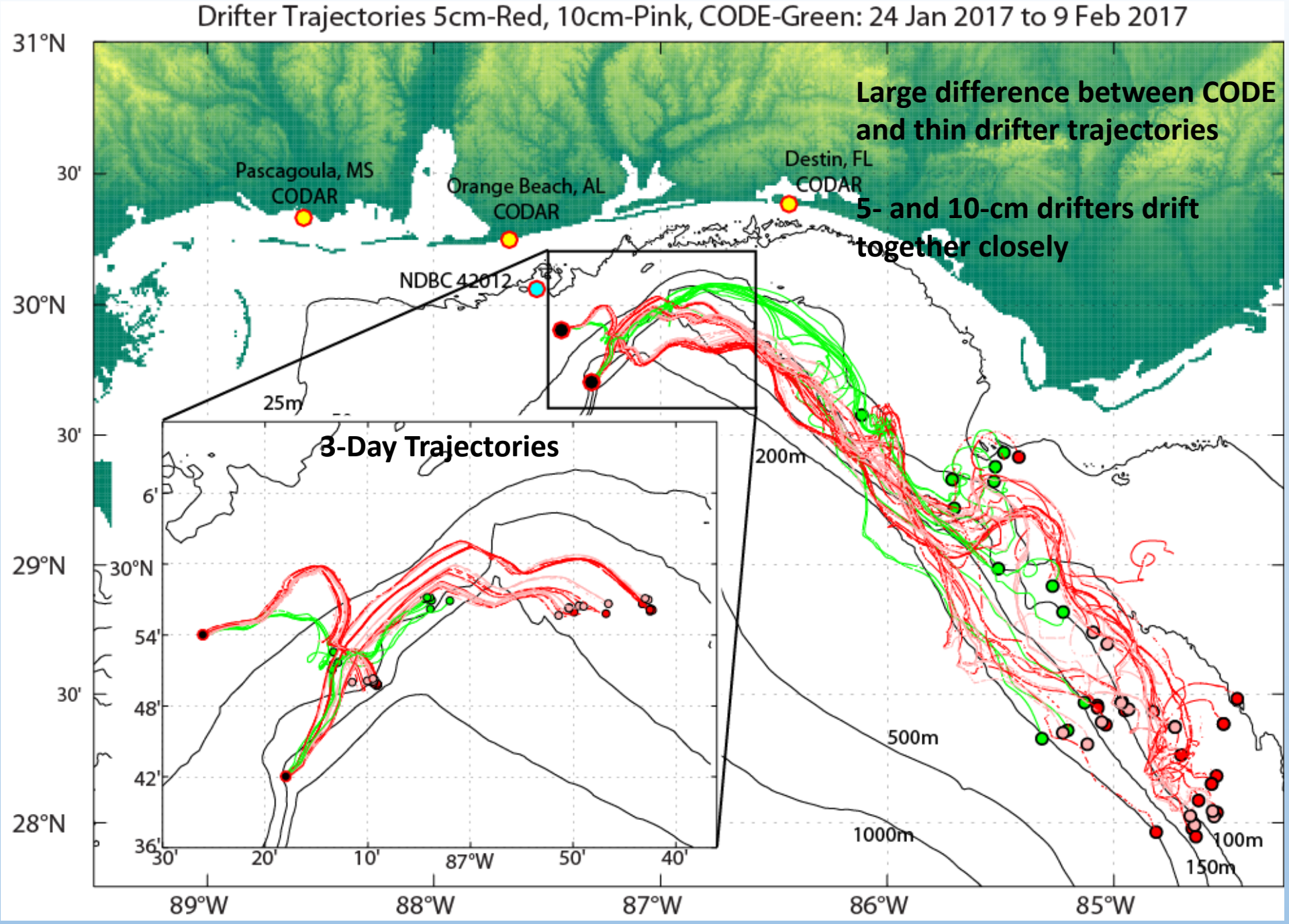
- Positions transmitted every 5 minutes



Deployment of drifters and drift cards in clusters with initial separation < 10 m

- Early initial separation between CODE and thin drifters
- Thin drifters closely followed Drift Cards


5cm–Red, 10cm–Pink, CODE–Green: 24–Jan–2017 17:22:30 to 24–Jan–2017 17:22:30
m
0
–100
–200
–300
–400
–500
–600
–700
–800
–900
–1000
30'
20'
10'
30°N
50'
30'
20'
10'
87°W
50'


Drifter Trajectories 5cm-Red, 10cm-Pink, CODE-Green: 24 Jan 2017 to 9 Feb 2017
Large difference between CODE and thin drifter trajectories
5- and 10-cm drifters drift together closely
Pascagoula, MS CODAR
Orange Beach, AL CODAR
Destin, FL CODAR
NDBC 42012
25m
200m
500m
1000m
100m
150m
3-Day Trajectories
31°N
30°N
29°N
28°N
89°W
88°W
87°W
86°W
85°W

# Drifter Velocity Comparison

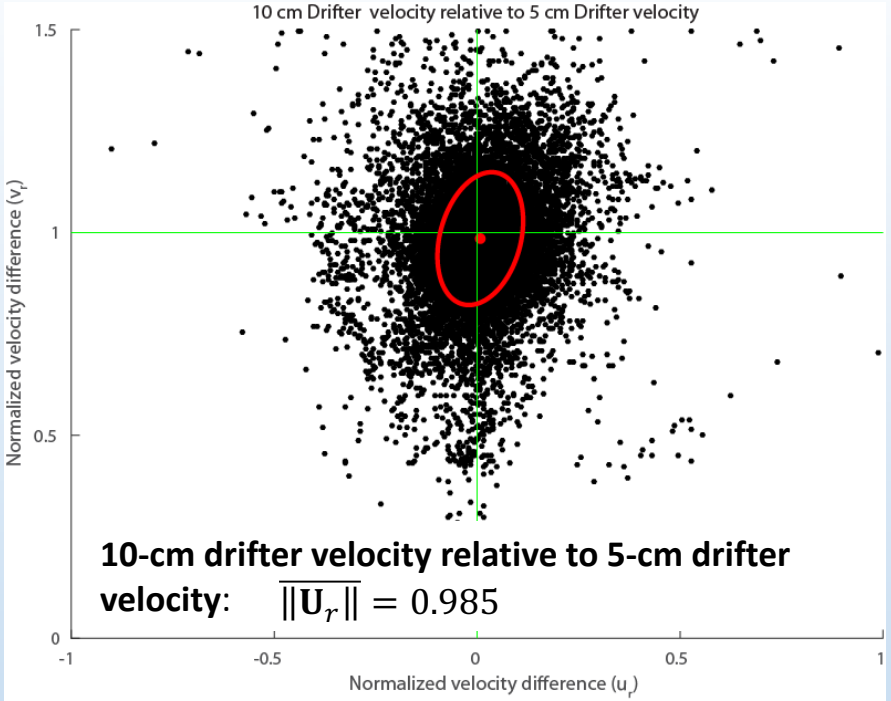
Velocity compared between co-located 5-cm and 10-cm drifters (<500m separation)

10-cm or CODE drifter velocity rotated and scaled relative to co-located 5-cm drifter velocity ($\mathbf{U_5}$):

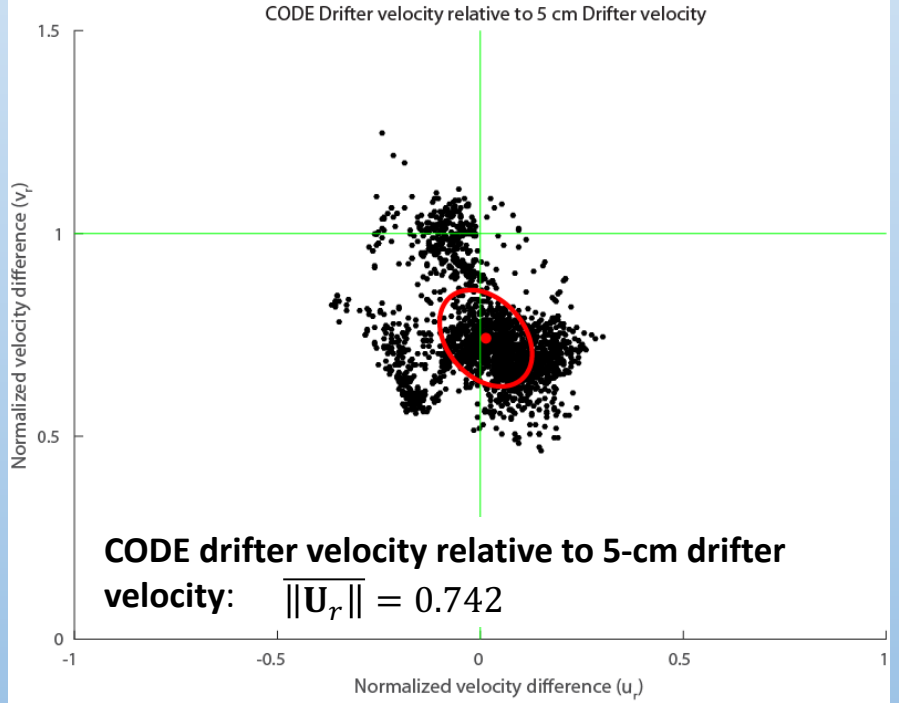
$$(u_r, v_r) = \frac{\mathbf{U}}{\mathbf{U}_5}\left(-\sin(\varphi - \varphi_5), \cos(\varphi - \varphi_5)\right)$$

$\varphi$: course over ground

Only computed for $\mathbf{U}_5$ > 0.2 m/s

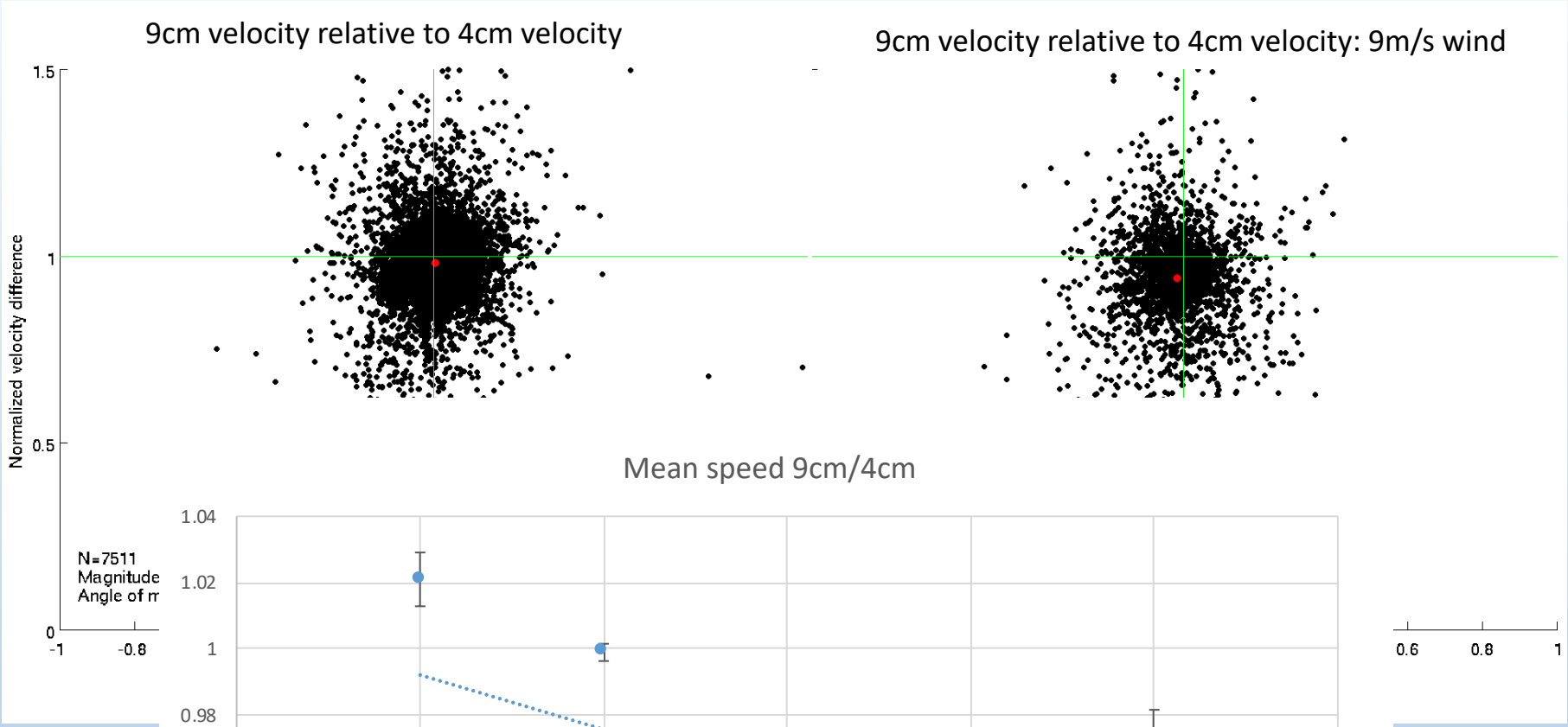


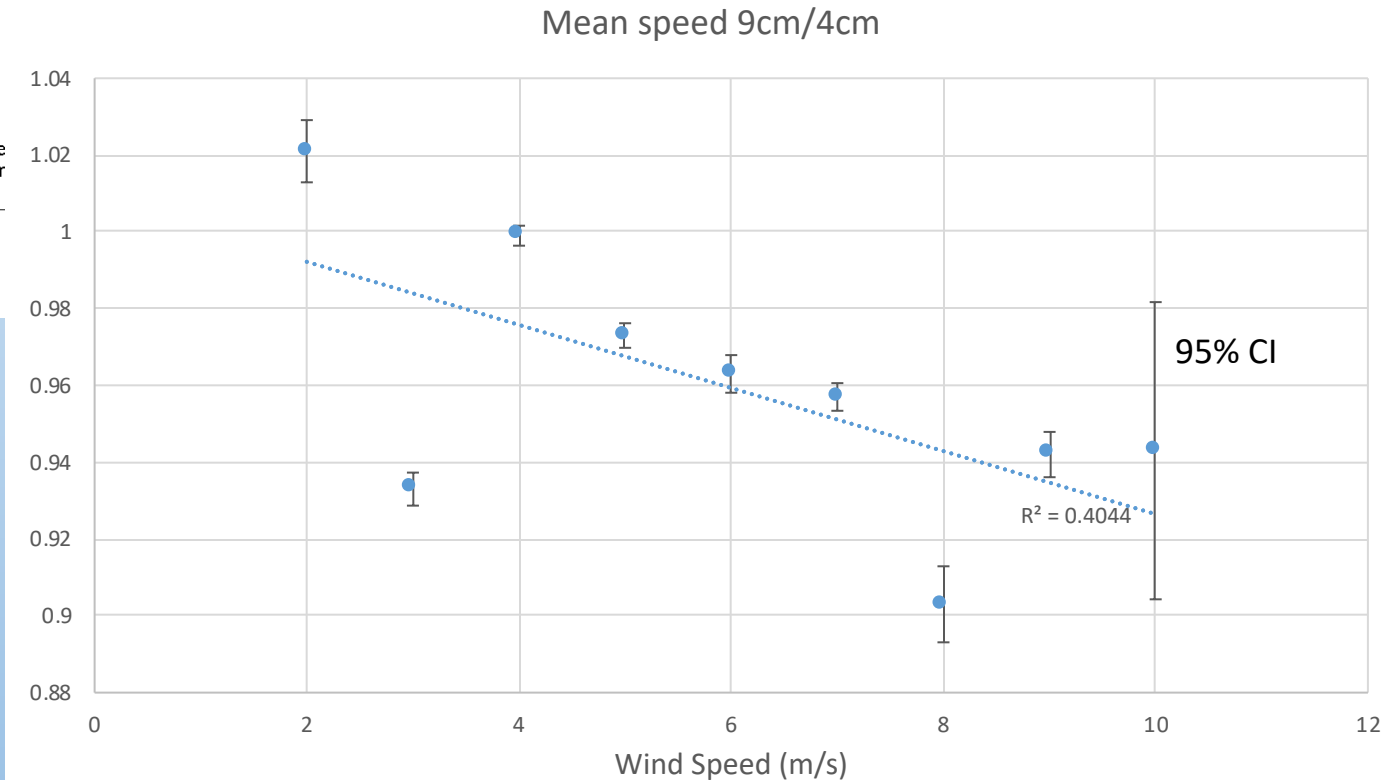

**10-cm drifter velocity relative to 5-cm drifter velocity**: $\overline{\|\mathbf{U}_r\|} = 0.985$



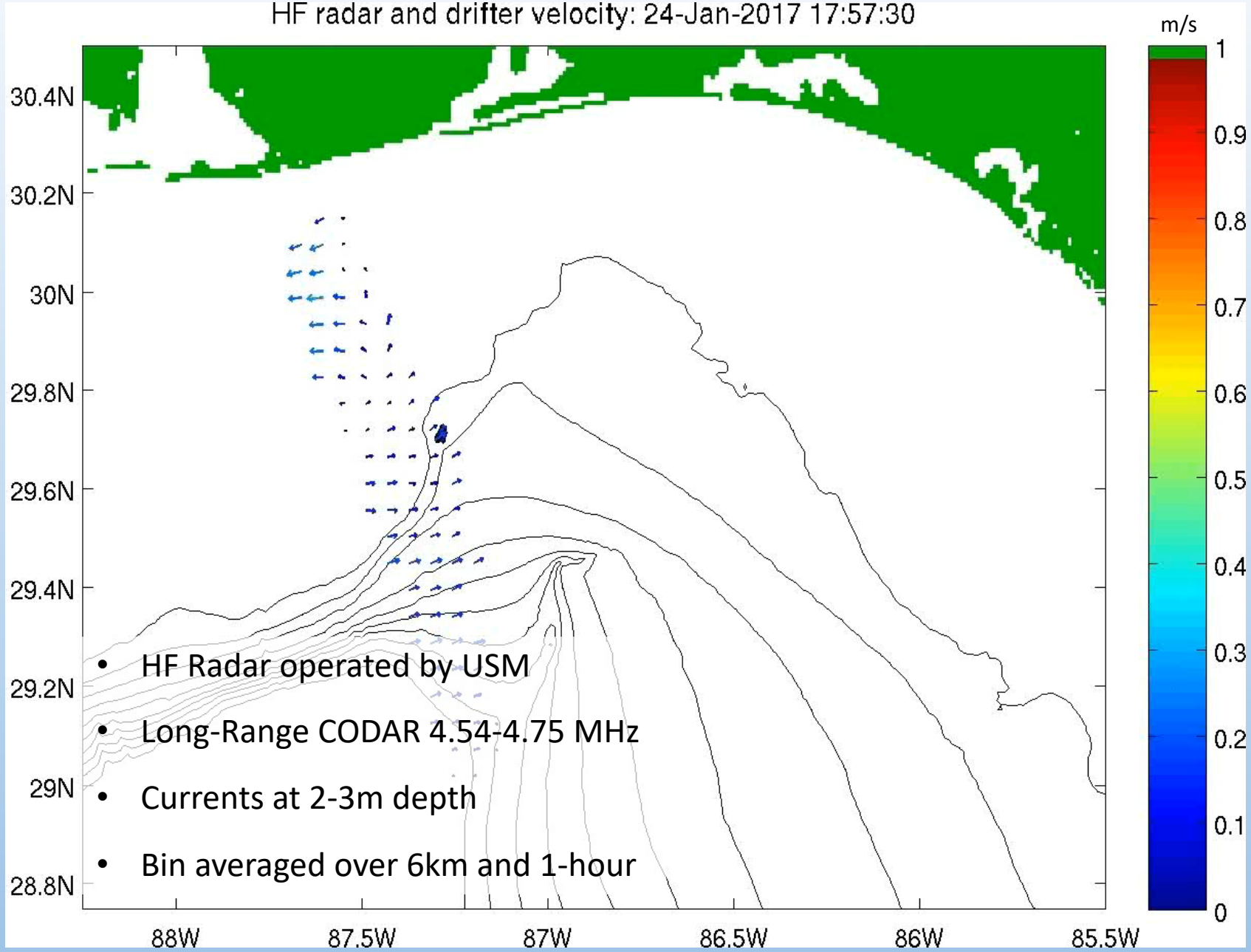

**CODE drifter velocity relative to 5-cm drifter velocity**: $\overline{\|\mathbf{U}_r\|} = 0.742$

# Upper 9cm velocity relative to 4 cm velocity – Dependence on Wind



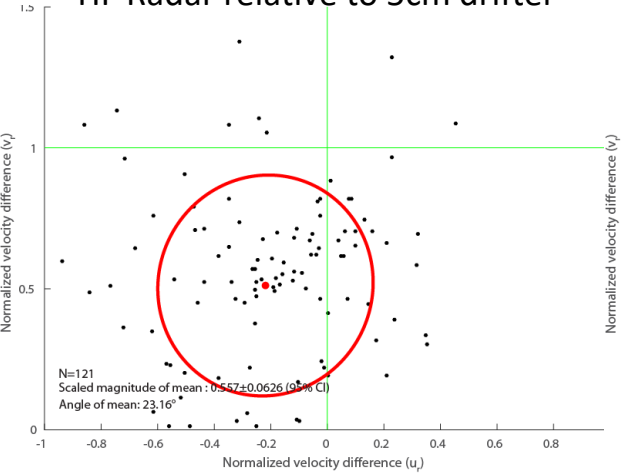



# Comparison with HF Radar

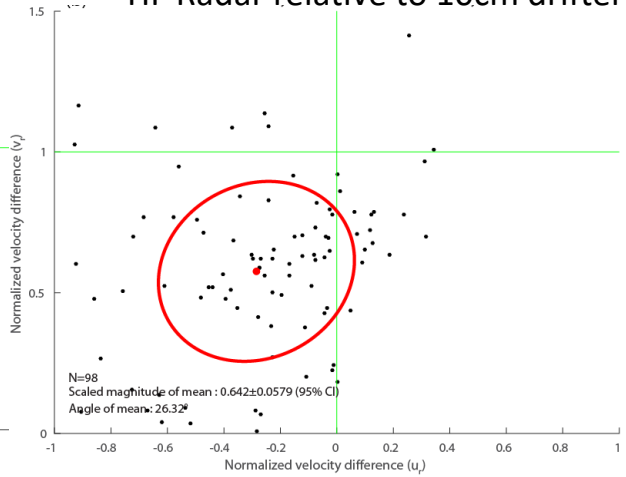


# HF Radar Velocity Relative to Bin-Averaged Drifter Velocity

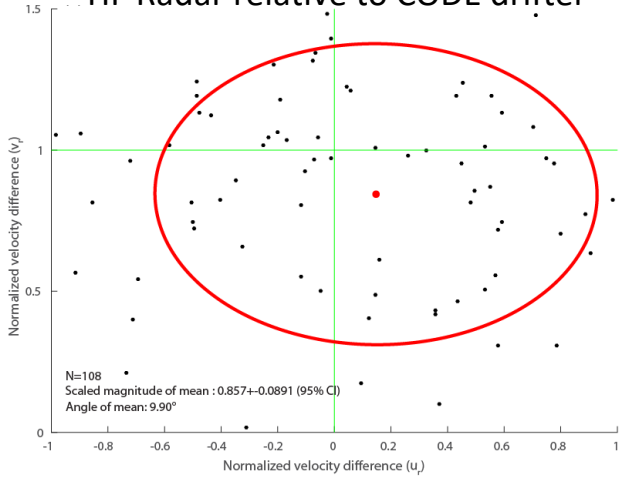
HF Radar relative to 5cm drifter

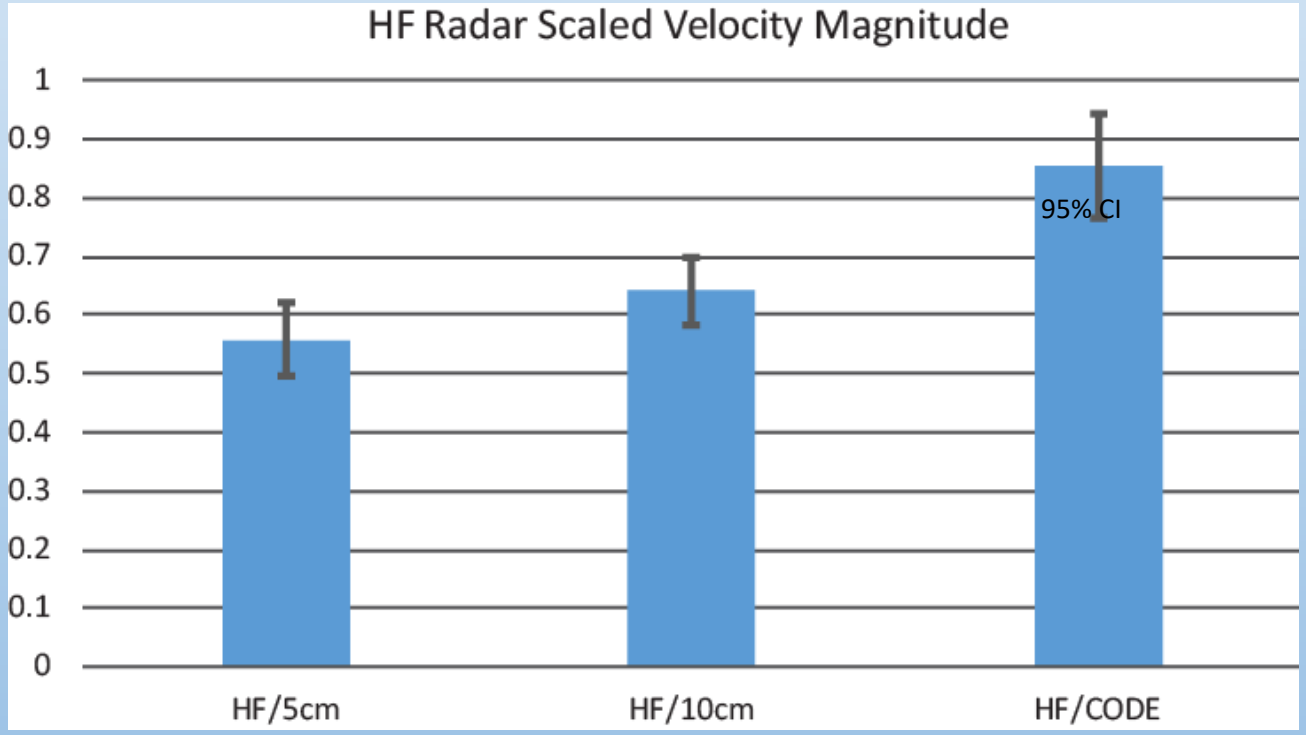



HF Radar relative to 10cm drifter




HF Radar relative to CODE drifter



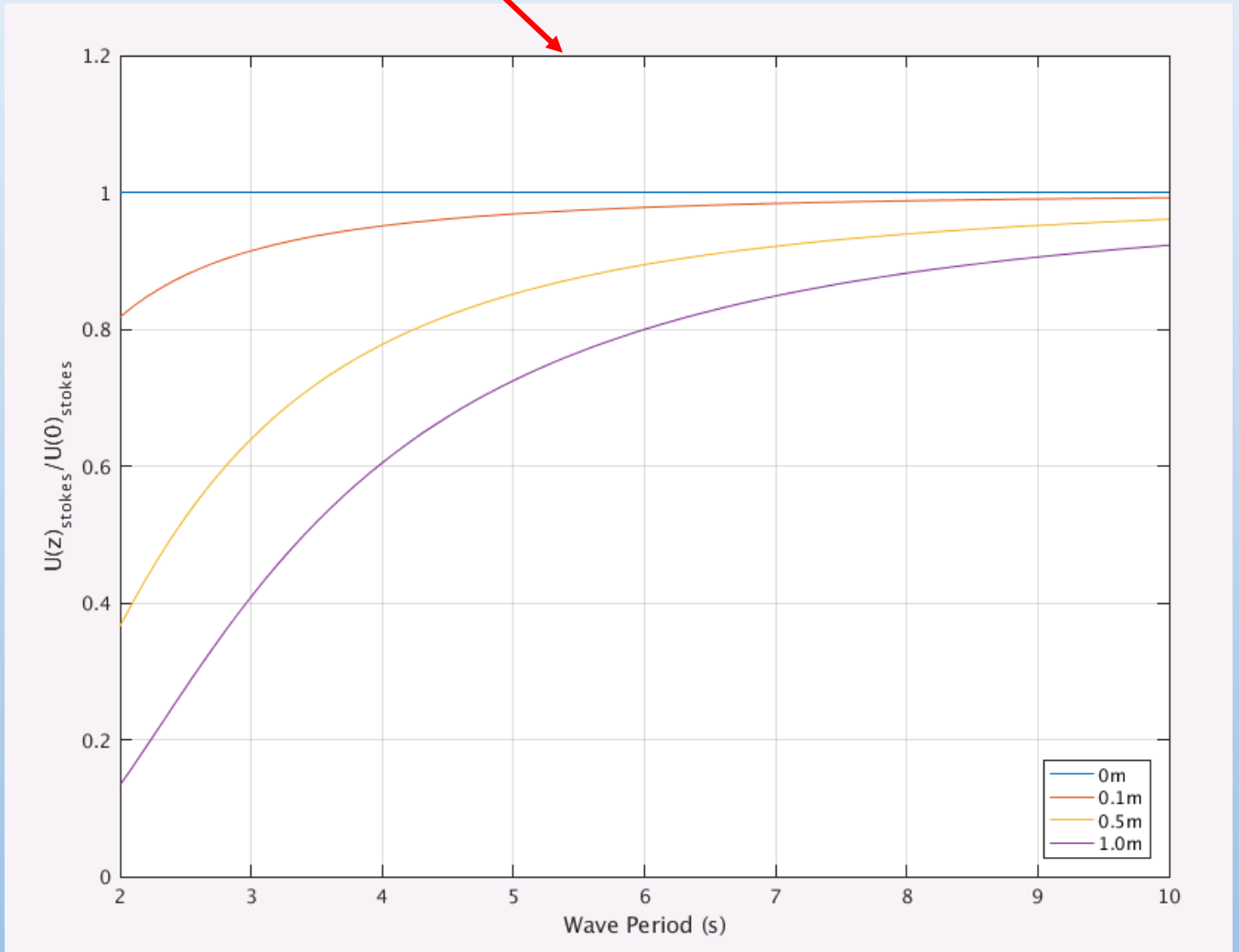



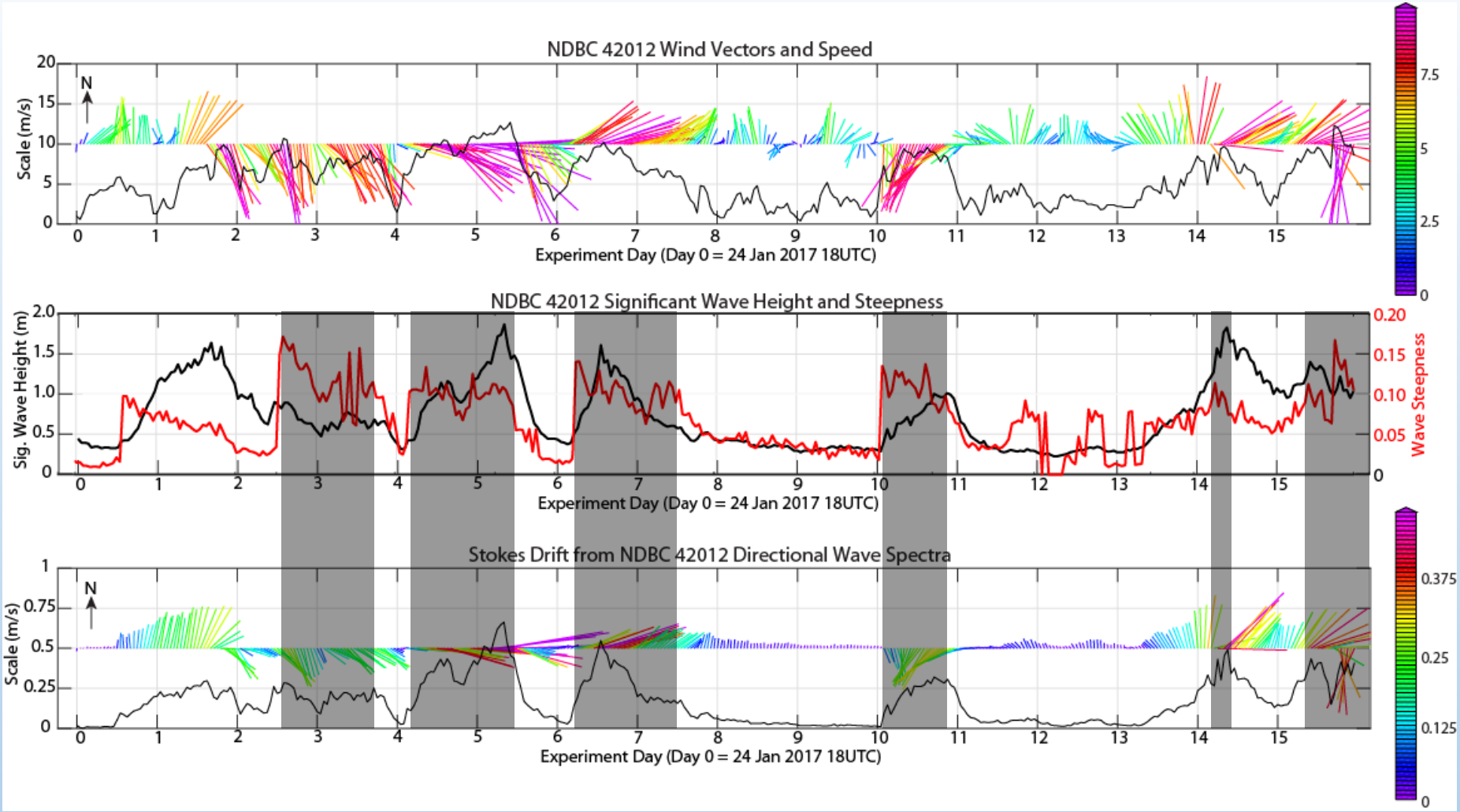
# Stokes Velocity Profiles

(*adapted from Kenyon, 1969*)

$$\boldsymbol{U_{Stokes}} = \frac{2}{g}\int_0^{\sigma_c}\int_{-\pi}^{\pi} e^{2kz}\sigma^3 F(\sigma,\theta)(\cos\theta\,,\sin\theta)d\theta d\sigma$$

σ - frequency
Θ - wave direction
F(σ, Θ) - wave spectrum
*k* - wavenumber

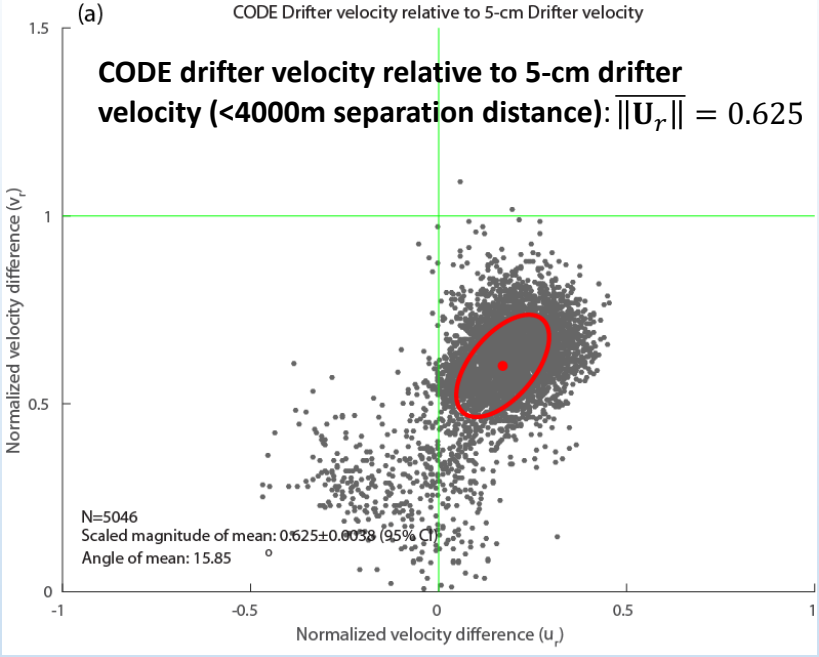


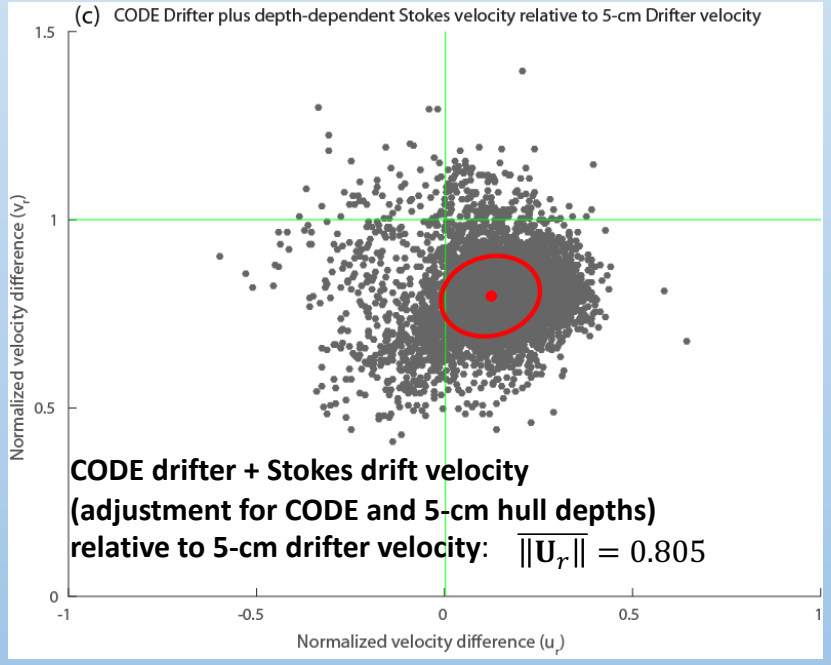


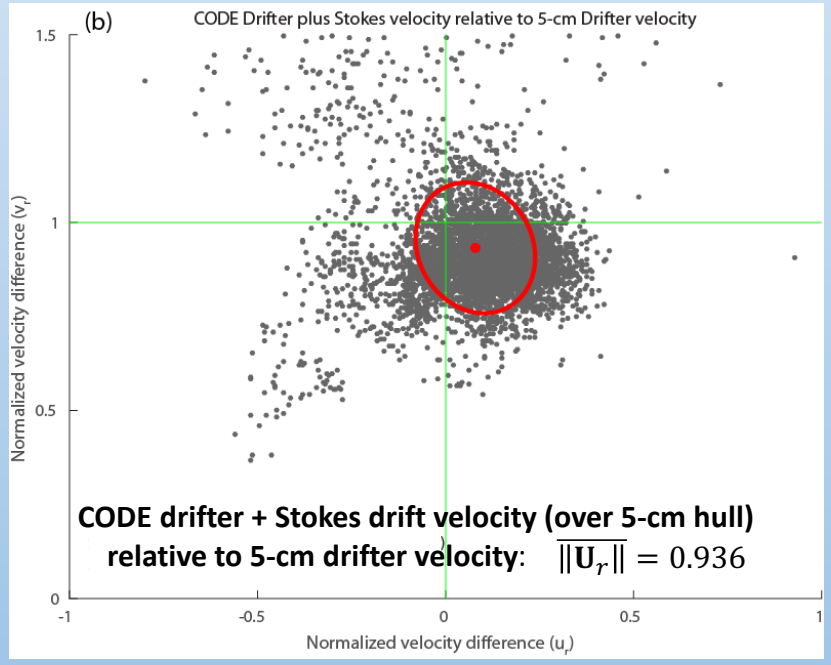

Wave breaking mixes momentum downward through the surface layer breaking down the exponential shear profile of the Stokes drift velocity (Melsom 1996).

Wave breaking occurs with greater likelihood (Pr > 0.05) when wave steepness > 0.1 (Banner et al., 2000).

Stokes drift velocity accounts for much of the difference between CODE drifter and 5-cm drifter velocity.



# Summary

- 5-cm and 10-cm drifters move with average relative velocity difference < 2%
  - Difference increases with wind speed

- Thin drifters move very differently from more commonly used CODE-style drifters.
  - CODE drifter velocity is approximately 26-35% slower than surface drifters

- HF Radar currents (approximately 2-3m depth) are ~44% slower than surface drifters

- HF radar velocity estimates more closely match CODE drifter velocity

- Stokes drift velocity accounts for most of the difference between the CODE and 5-cm drifter velocity.

- Accounting for theoretical stokes drift velocity over the CODE drifter drogue area reduces the match – possibly due to CODE drifters not following the shortest waves.