Wind Drift Currents from Remote Sensing

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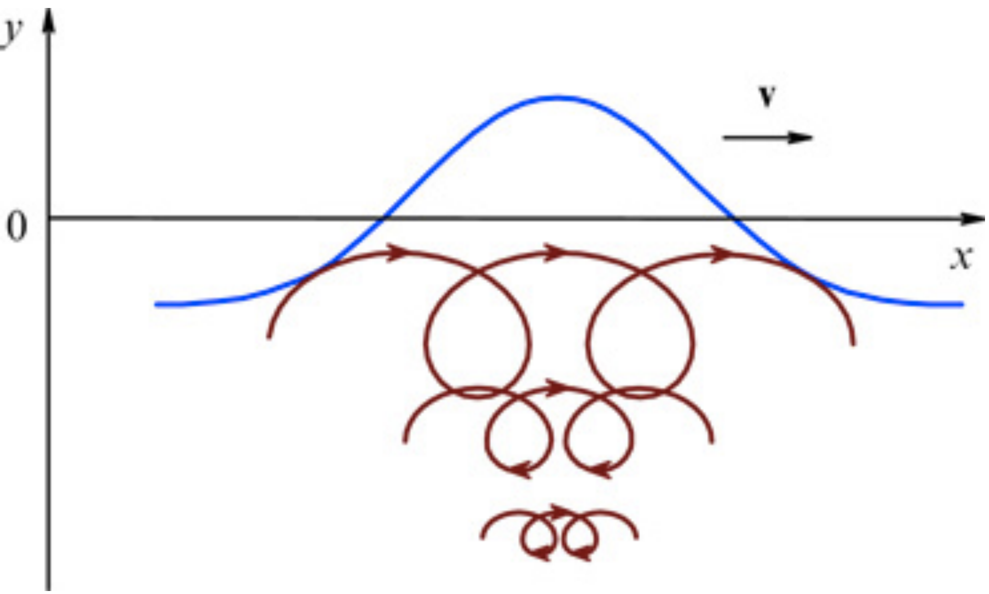
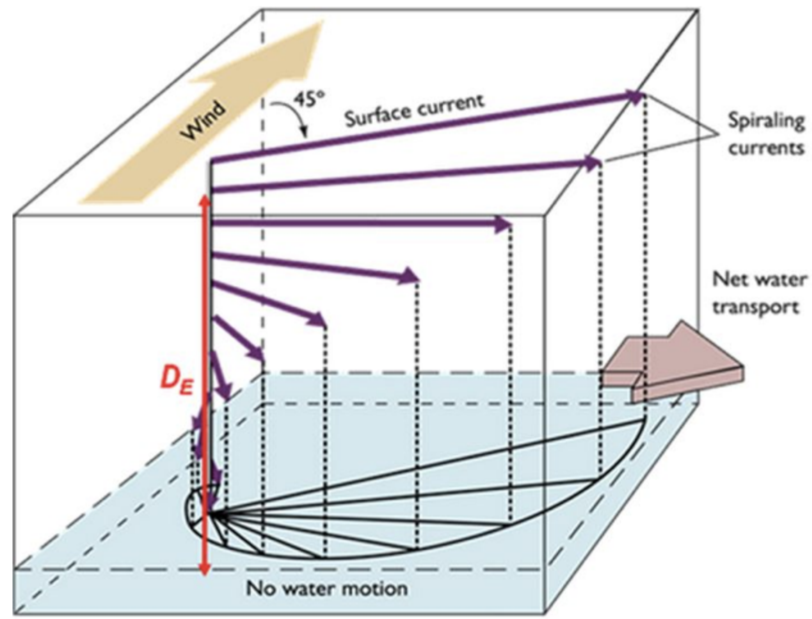
Stokes & Ekman

Stokes Lagrangian Current



Ekman Eulerian Current

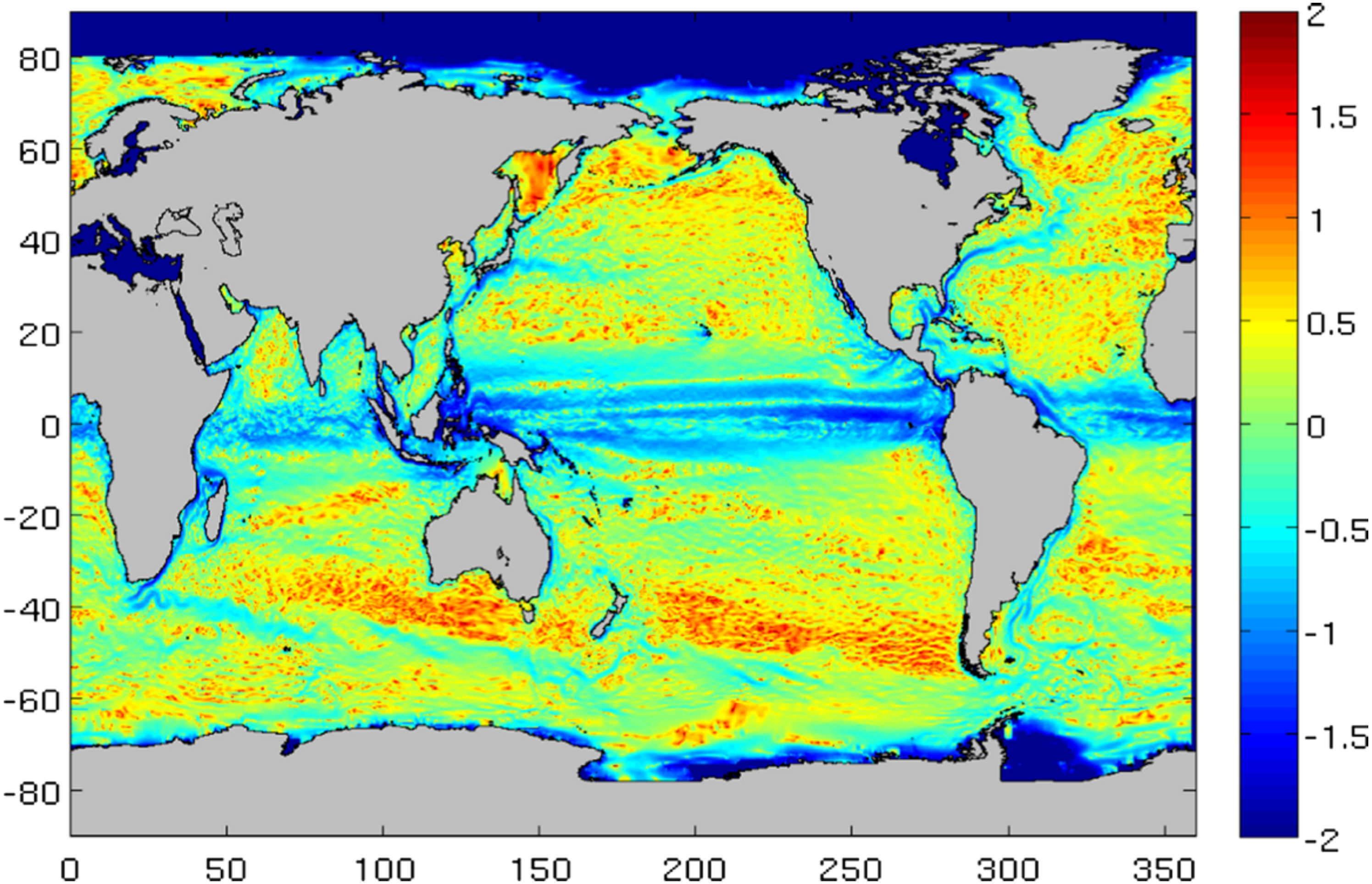


(a) EKMAN SPIRAL IN THE NORTHERN HEMISPHERE

$$\mathbf{u}_{\mathrm{Stokes}} = a^2\omega^3 g^{-1} \exp(2kz)\,\mathbf{e}_{\mathrm{wave}}.$$

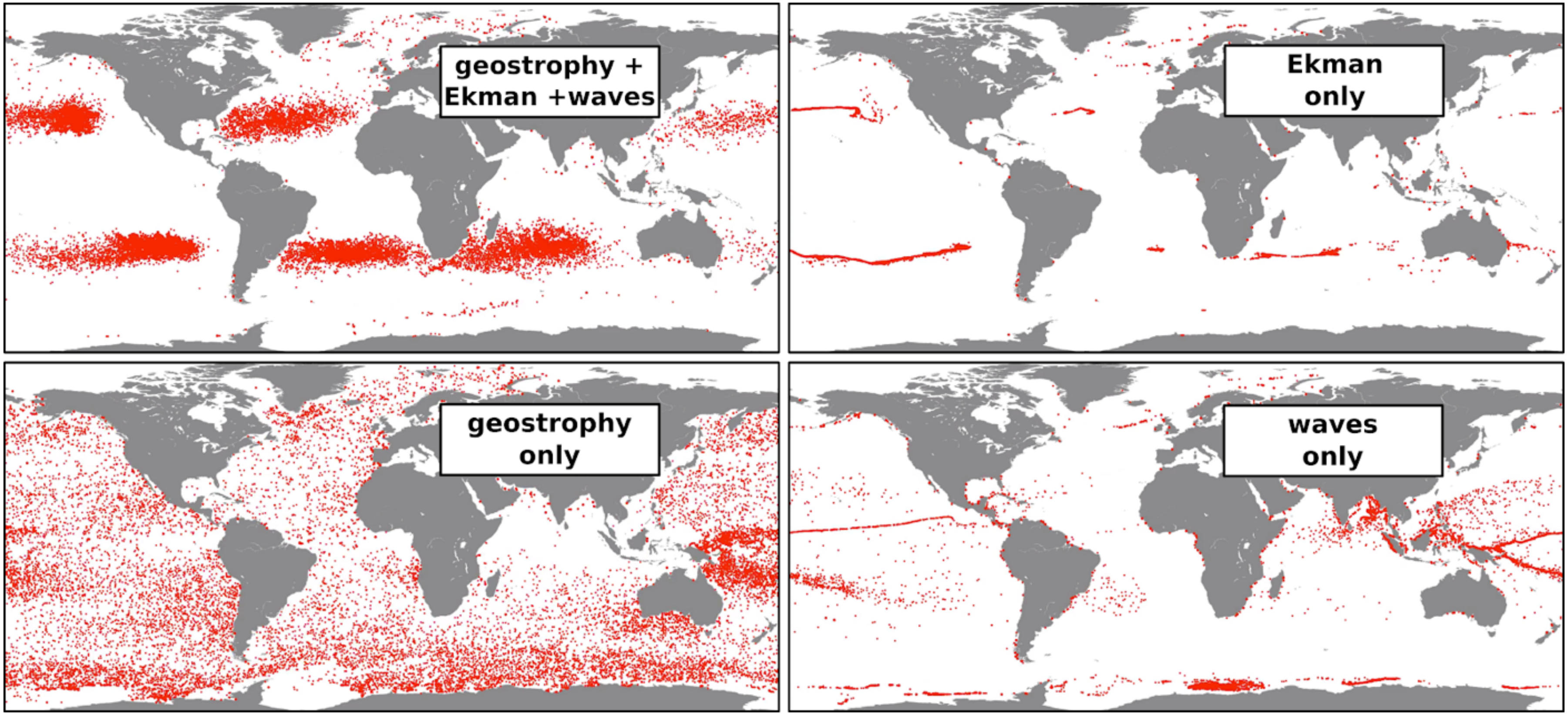
$$\vec{u}_{ek}(z) = \beta(z)\vec{\tau}e^{i\theta(z)}$$

Ratio of Stokes Drift to Geostrophic Currents



Ratio of climatological surface Stokes drift speed over climatological surface geostrophic speed. The scale is logarithmic. The Stokes drift is calculated from spectra of ECMWF ERA-40 reanalysis and averaged over 45 years. The geostrophic currents come from a 15-year average of altimeter and in situ observations from AVISO (Carrasco et al, Ocean Dynamics, 2014)

Advection of Surface Passive Tracers (aka, garbage)

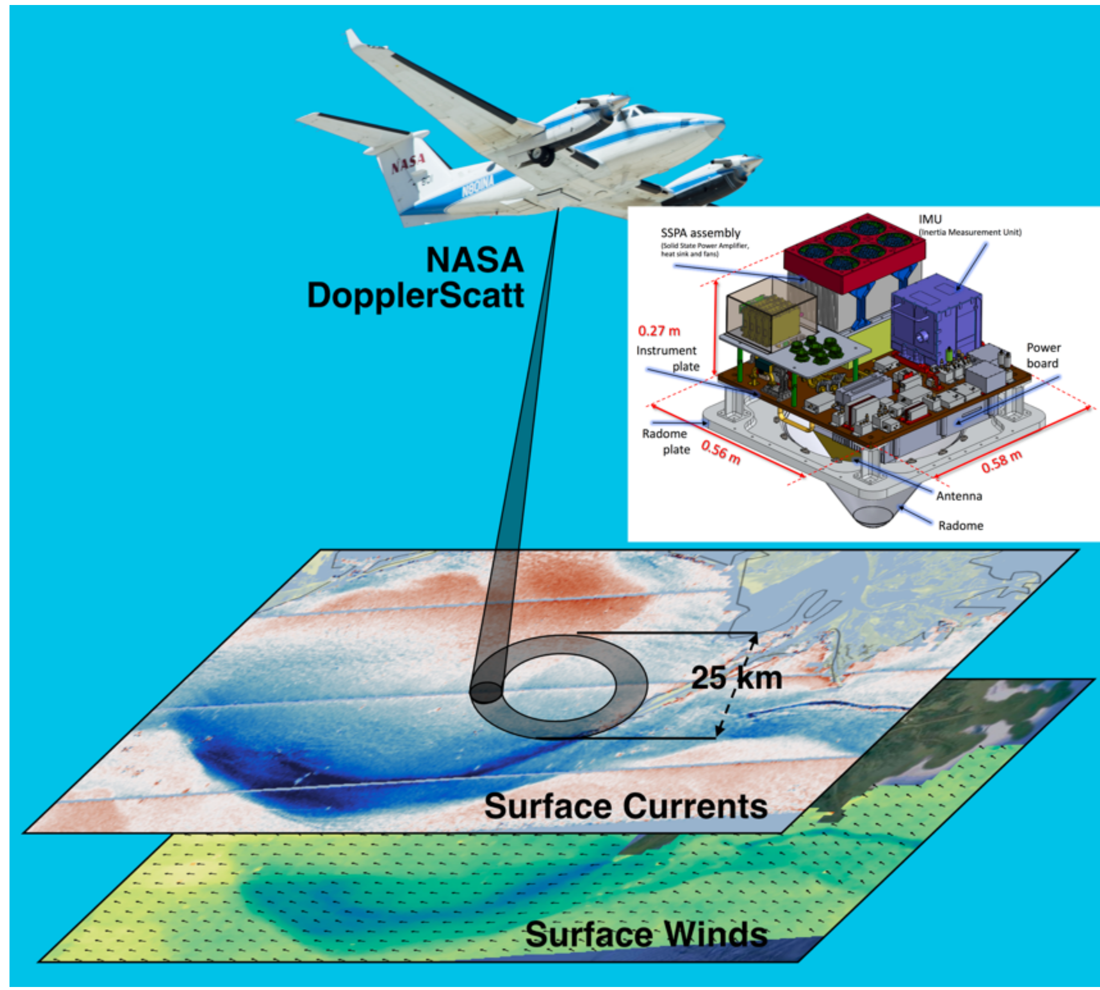


Distributions of virtual surface particles, after 10 years starting from a uniform distribution. The four panels show the effect of three components of the surface current combined or their effect taken separately (Adapted from Onink et al., 2019)

Why DopplerScatt for Wind Drift?

DopplerScatt provides wind **stress** and volicity directions & wind speed.

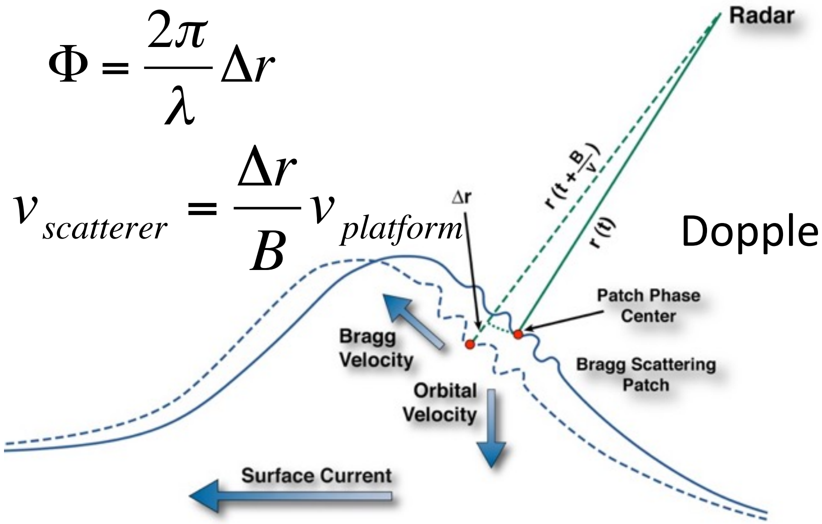
Coincident data over different wind conditions with HF Radar & ROCIS



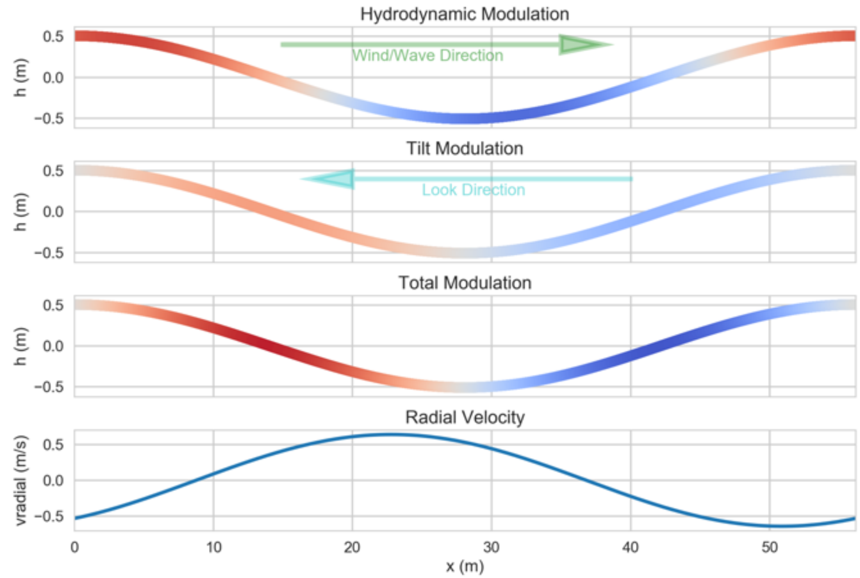
What velocity is measured?

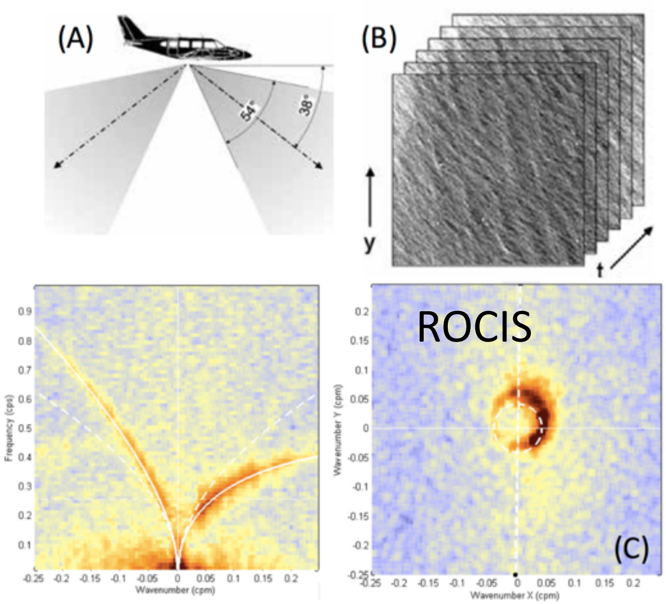
$$\Phi = \frac{2\pi}{\lambda}\Delta r$$

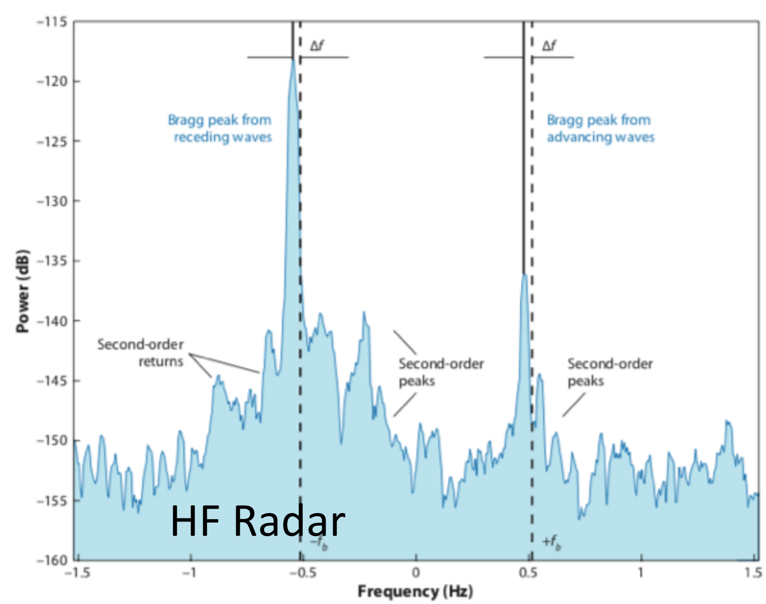
$$v_{scatterer} = \frac{\Delta r}{B} v_{platform}$$



DopplerScatt







What different instruments measure

$$\omega = \sqrt{gk} + \mathbf{k} \cdot \mathbf{U}_s$$

$\mathbf{U_M = U_E + U_{Sf}}$ HF Radar (Ardhuin et al., 2009)

$\mathbf{U_M = U_E + U_S/2}$ DopplerScatt (Rodriguez et al., 2018)

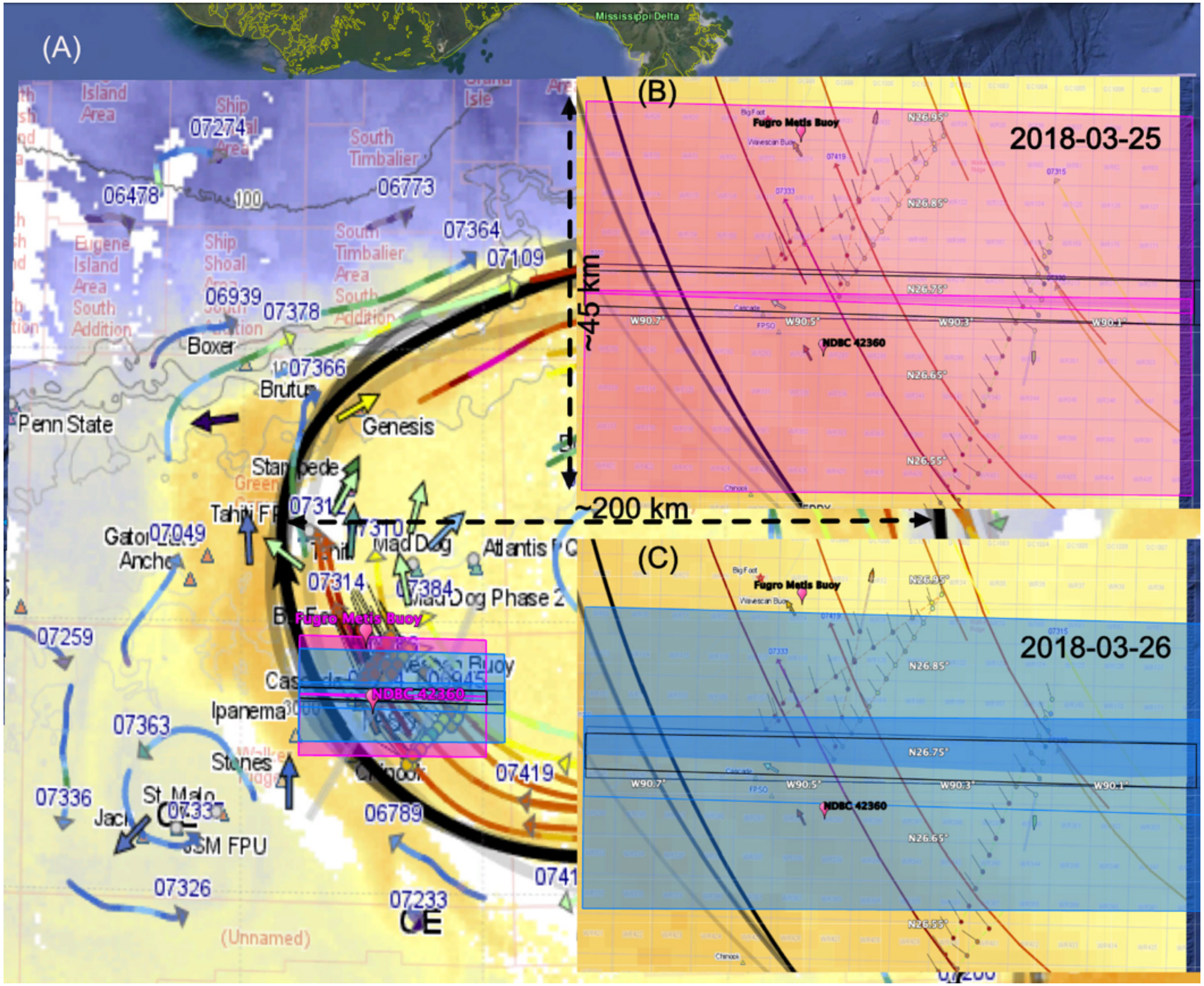
$\mathbf{U_M = U_E}$ ROCIS (Anderson et al., 2015)

Measured Eulerian velocity is average over the wavelength of the waves used

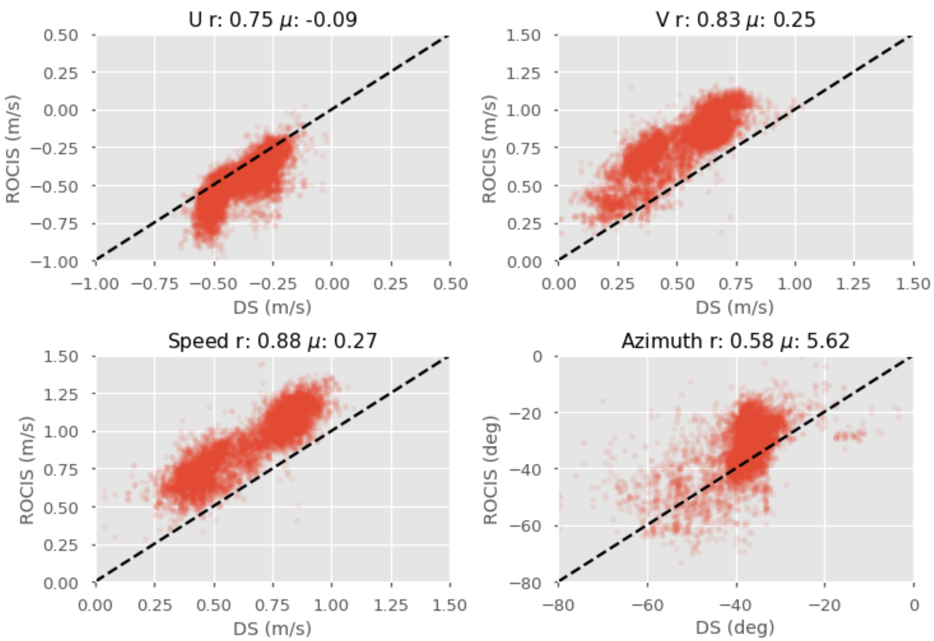
$$\mathbf{U}_E = 2k_B \mathbf{e}_{\theta_B} \cdot \int_{-\infty}^{0} \hat{\mathbf{u}} \exp(2k_B z)\, dz$$ Stewart & Joy, 1974

HF radar (5 MHz): ~2m depth
HF radar (12.5 MHz): ~1m depth
ROCIS: ~1m - 2m
DopplerScatt: <1mm

DopplerScatt Quantum Eddy Validation

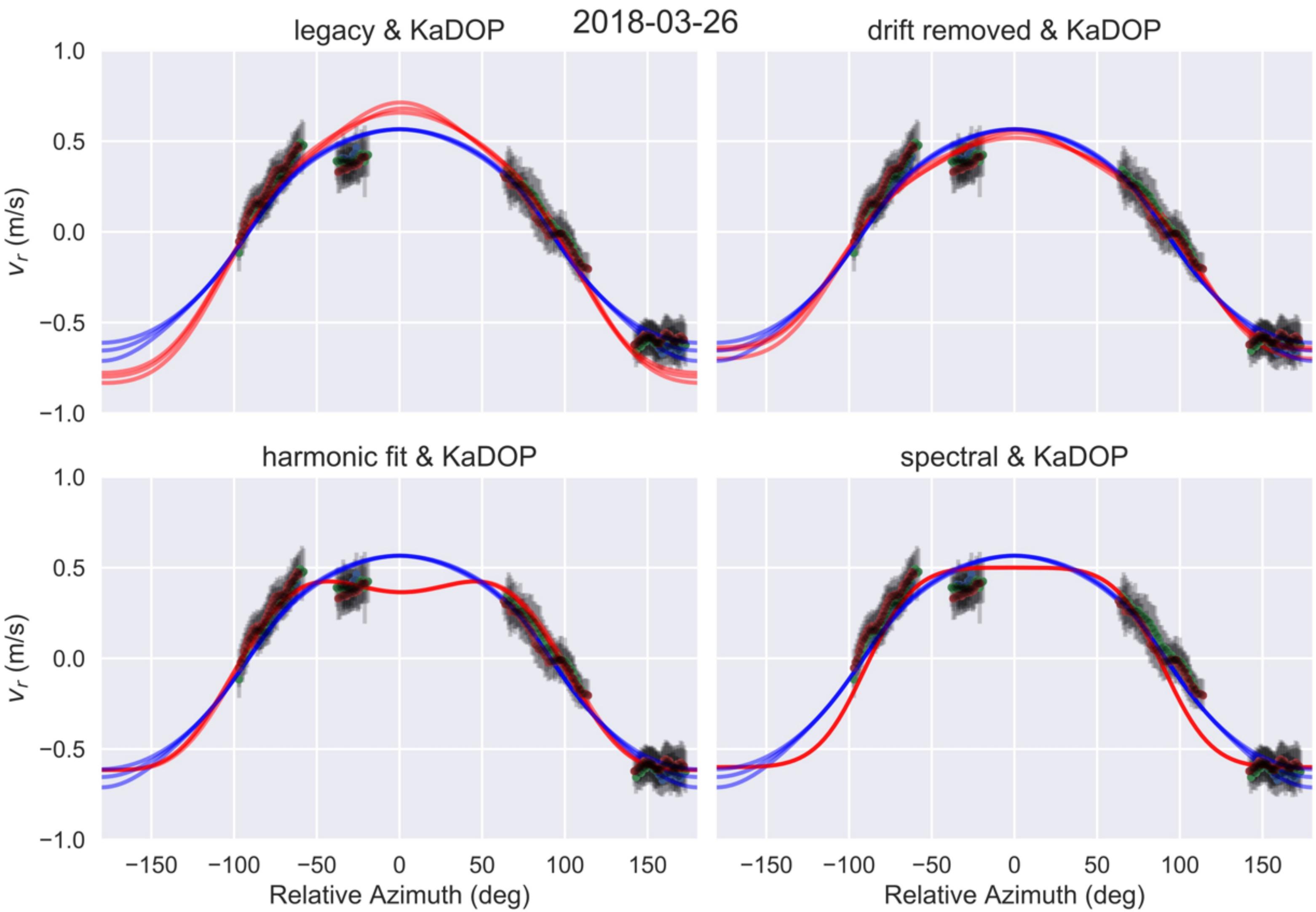


Velocity Differences



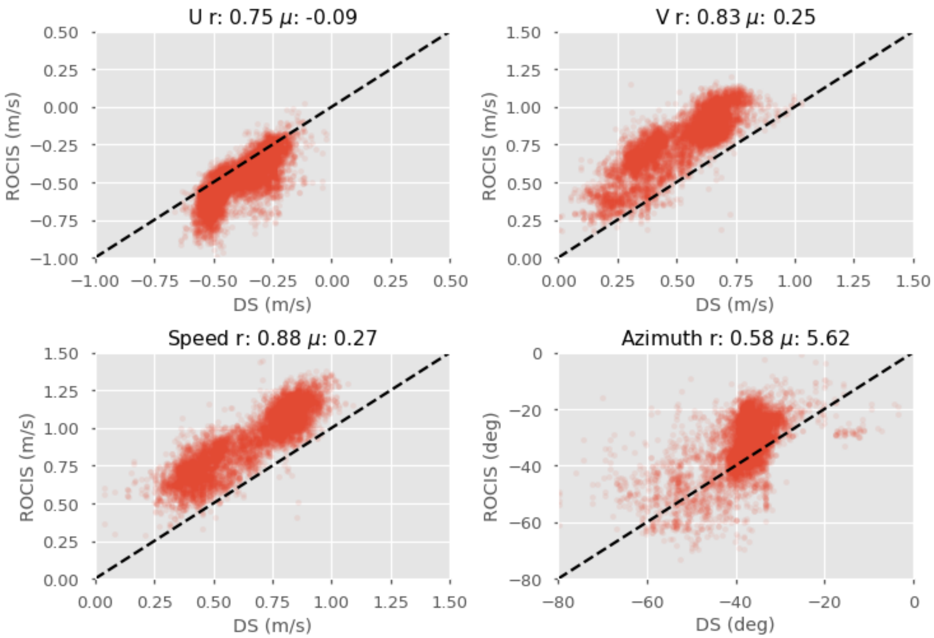
CGMF: Wind Drift Uncorrected

Problem Traced to Current GMF Correction Included Wind Drift

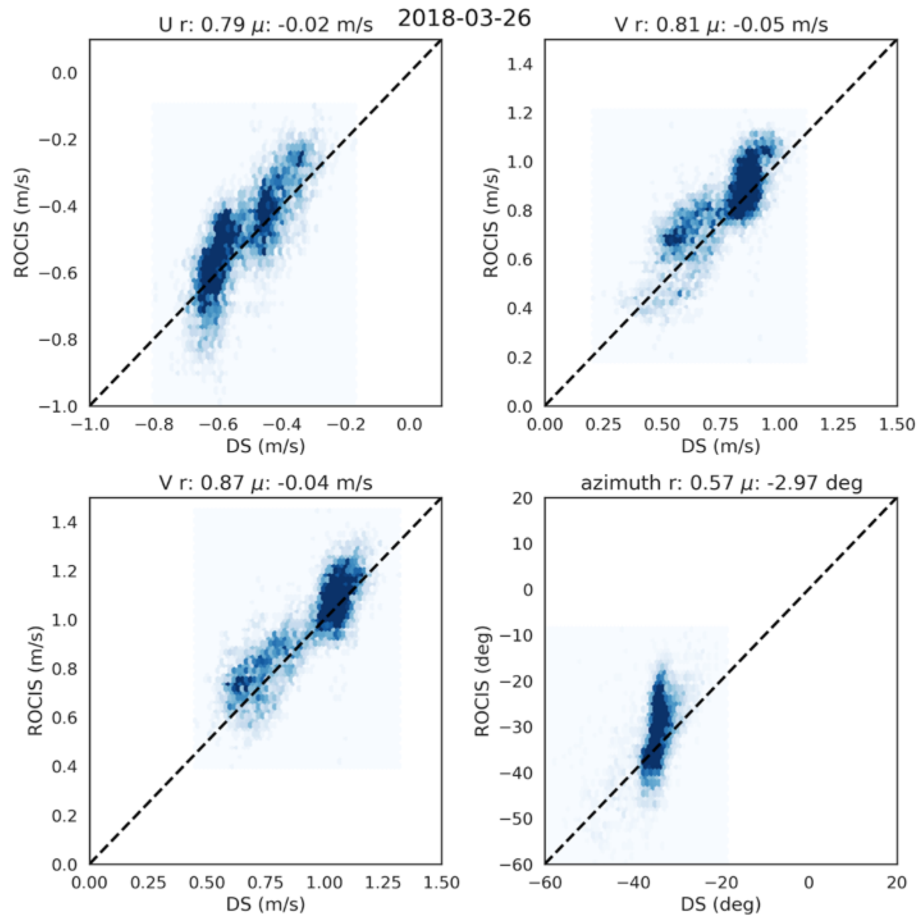


Blue line, Yurovsky et al., Black Sea Tower experiment.

Velocity Differences

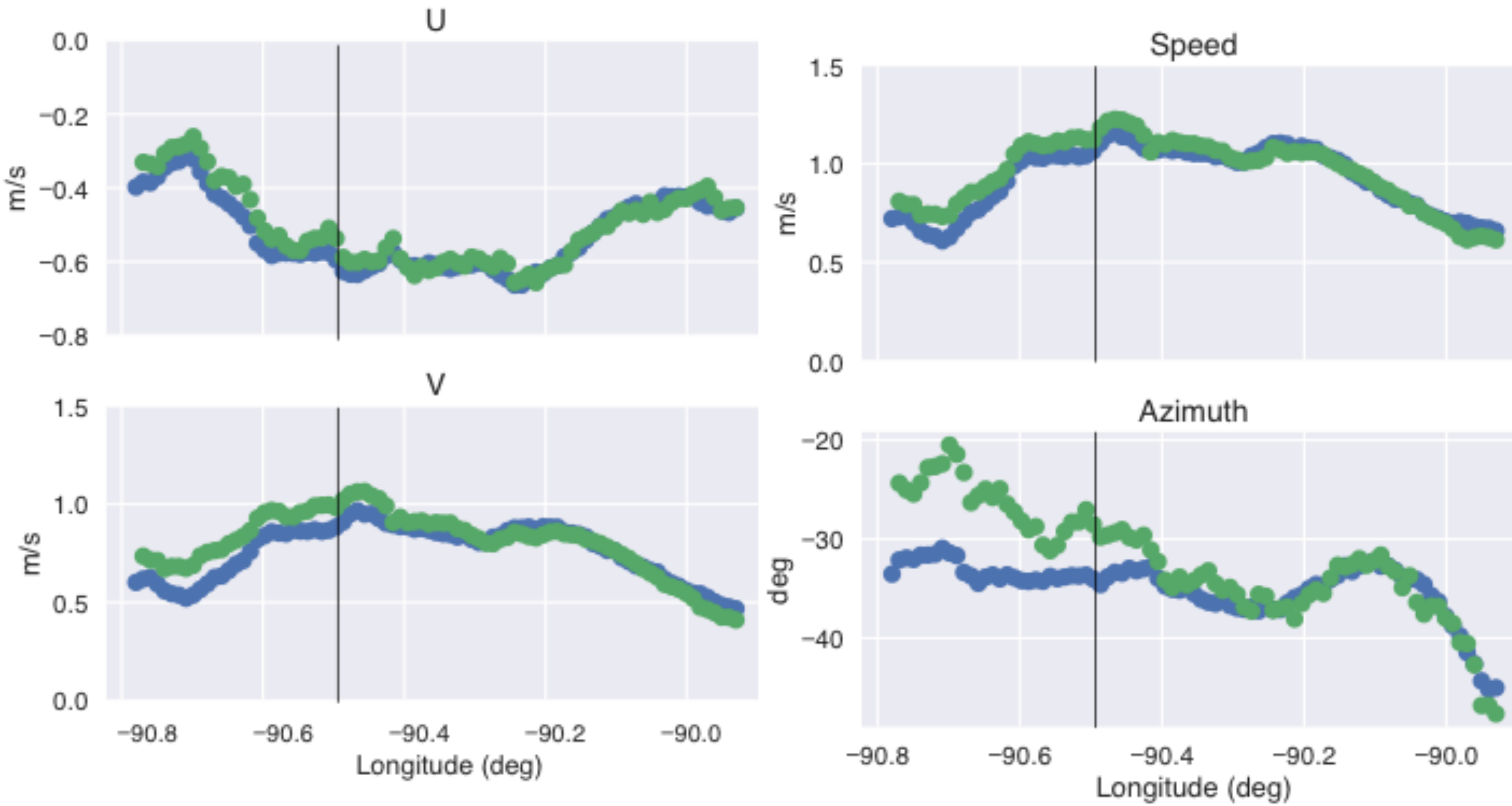


CGMF: Wind Drift Uncorrected



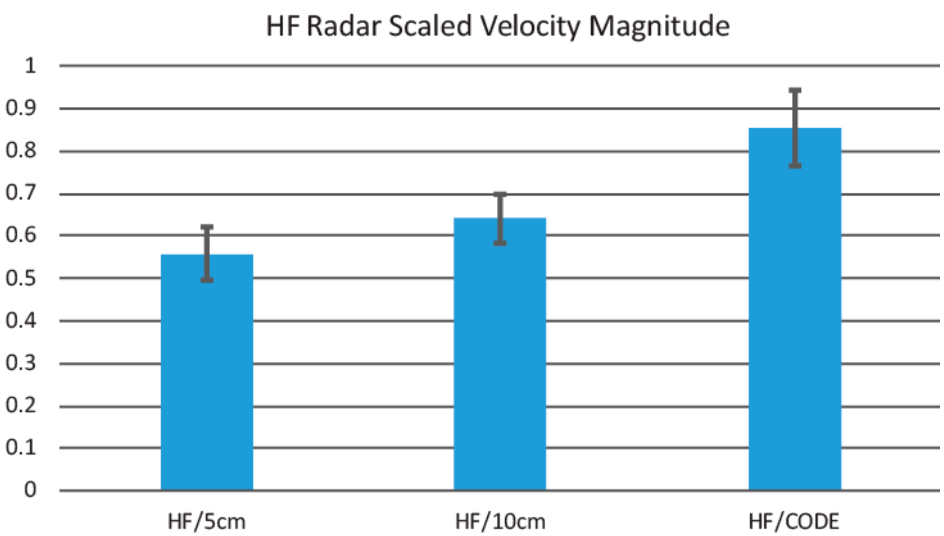
CGMF: Wind Drift Corrected

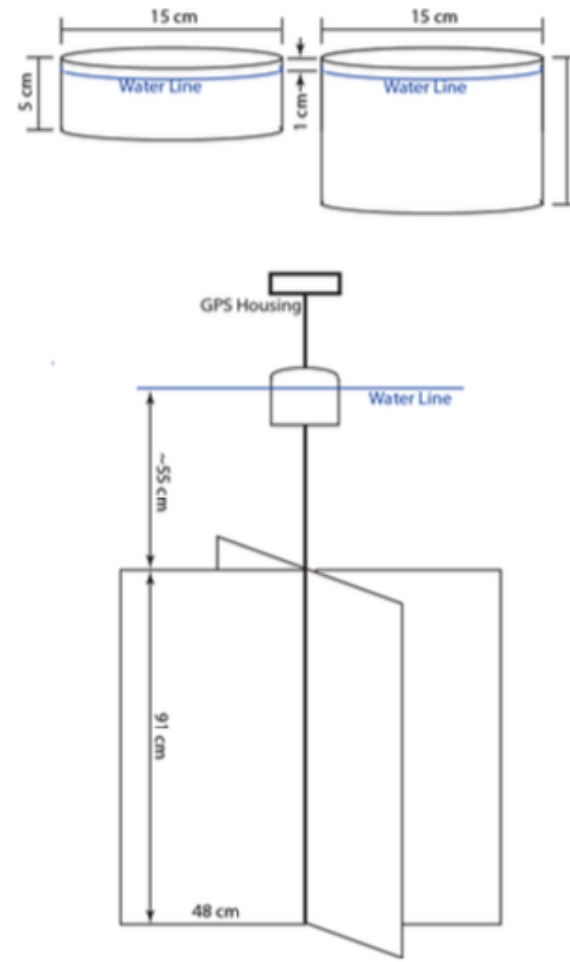
DopplerScatt – ROCIS Comparison



Data collection funded by Chevron. ROCIS data courtesy of Areté Associates.

HF Radar vs Drifters Drogued at Different Depths





remote sensing

MDPI

Article

Measurement Characteristics of Near-Surface Currents from Ultra-Thin Drifters, Drogued Drifters, and HF Radar

Steven L. Morey [1,2,*], Nicolas Wienders [3], Dmitry S. Dukhovskoy [2] and Mark A. Bourassa [3]

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Effects of Stratification

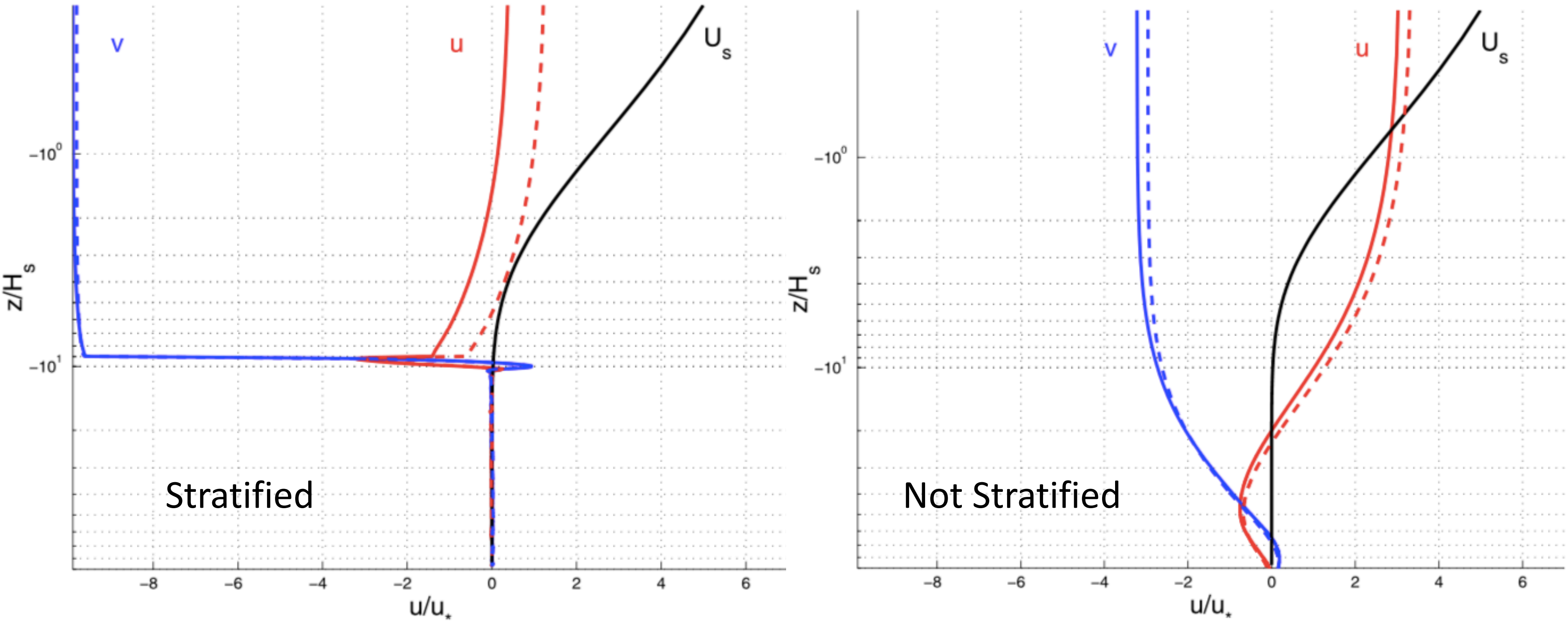

Figure 1. Velocity profiles from the model. $\widehat{u}$ is the downwind quasi-Eulerian velocity, $\widehat{v}$ is the crosswind quasi-Eulerian velocity, and U_s is the Stokes drift. Velocities and elevation are normalized by the waterside friction velocity u_* and by the significant wave height H_s, respectively. Solid lines and dashed lines are model results with and without the Stokes-Coriolis effect, respectively. (top) With a 20-m–deep mixed layer as observed during SMILE. (bottom) Without the effect of stratification.

Drift and mixing under the ocean surface revisited: Stratified conditions and model-data comparisons

JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 114, C02016, doi:10.1029/2007JC004466, 2009

Nicolas Rascle[1,2] and Fabrice Ardhuin[1]

Current Shear from Measurements

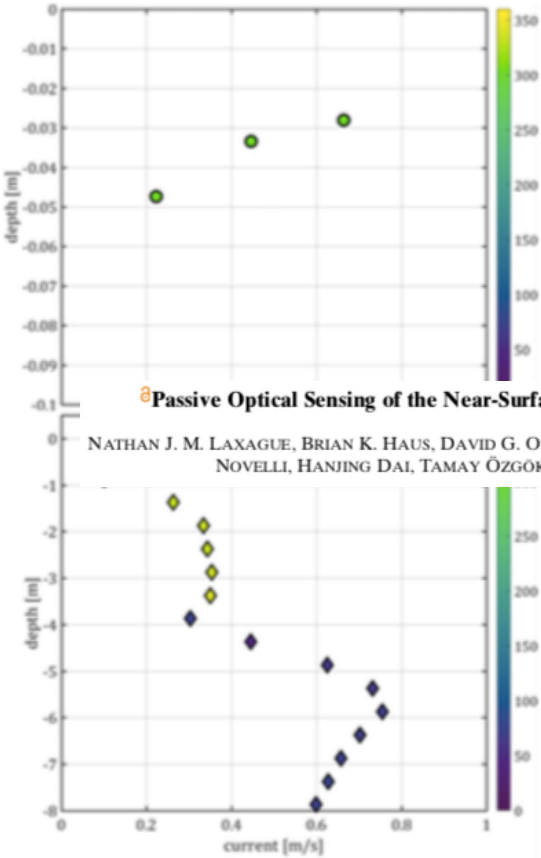

FIG. 11. The time-averaged current profile for MCR-1. (bottom) Full derived profile and (top) an expansion of the upper 0.1 m of the profile. Data presented include current observations from the polarimetric wave slope sensing method (●) and the moored ADCP (◆). Each symbol's fill color corresponds to its direction (deg) clockwise from true north in an oceanographic going-to convention. Wind velocity direction: 12.74°, wind velocity magnitude: 9.14 m s^{-1}; wind stress direction: 351.85°, wind stress magnitude: 0.0508 N m^{-2}.

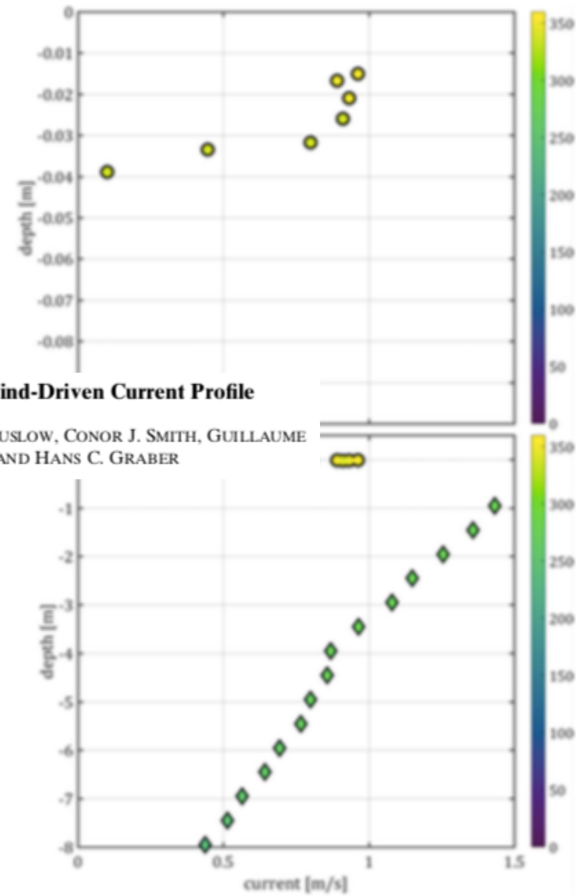

FIG. 13. The time-averaged current profile for MCR-2. (bottom) Full derived profile and (top) an expansion of the upper 0.1 m of the profile. Data presented include current observations from the polarimetric wave slope sensing method (●) and the moored ADCP (◆). Each symbol's fill color corresponds to its direction (deg) clockwise from true north in an oceanographic going-to convention. Wind velocity direction: 321.48°, wind velocity magnitude: 10.99 m s^{-1}; wind stress direction: 326.72°, wind stress magnitude: 0.0175 N m^{-2}.

Passive Optical Sensing of the Near-Surface Wind-Driven Current Profile

NATHAN J. M. LAXAGUE, BRIAN K. HAUS, DAVID G. ORTIZ-SUSLOW, CONOR J. SMITH, GUILLAUME NOVELLI, HANJING DAI, TAMAY ÖZGÖKMEN, AND HANS C. GRABER

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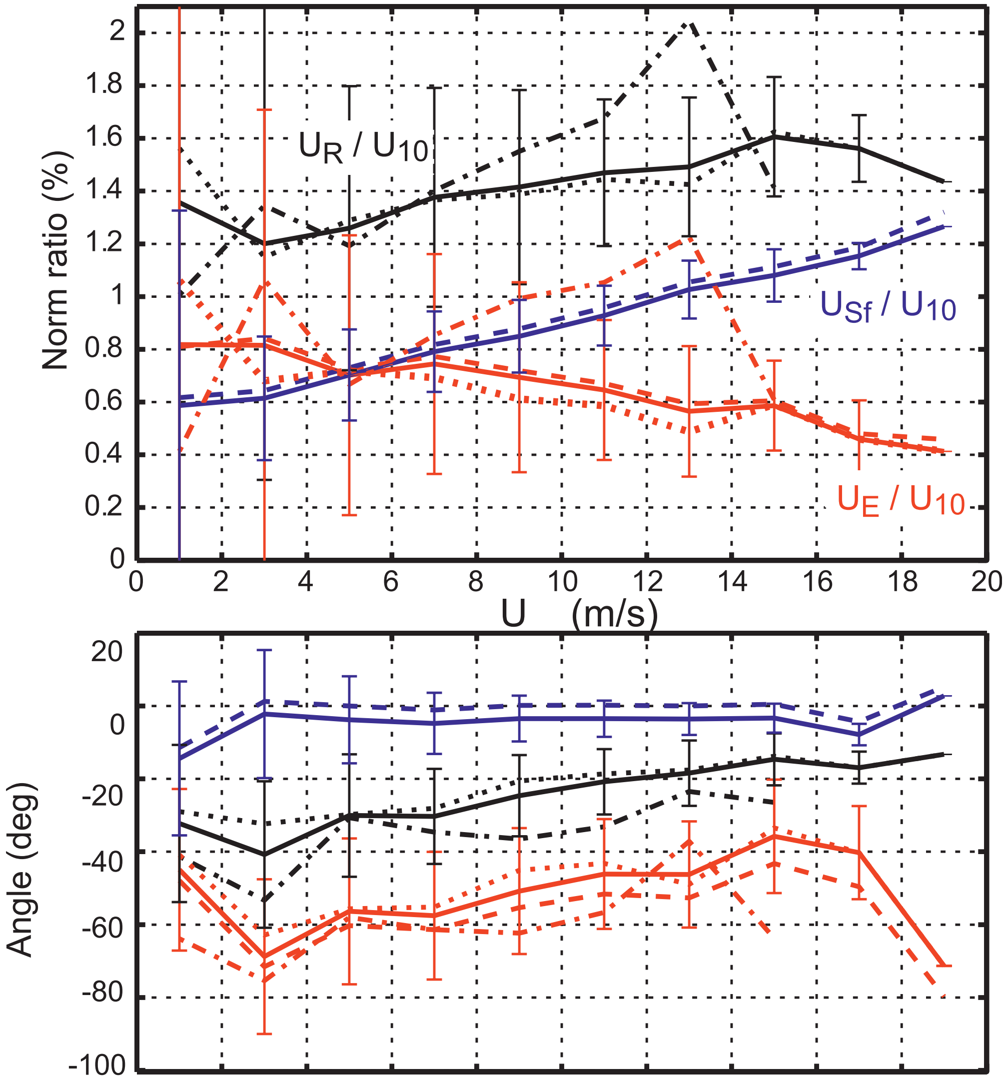
Wind Drift Decomposition



JOURNAL OF PHYSICAL OCEANOGRAPHY VOLUME 39

Observation and Estimation of Lagrangian, Stokes, and Eulerian Currents Induced by Wind and Waves at the Sea Surface

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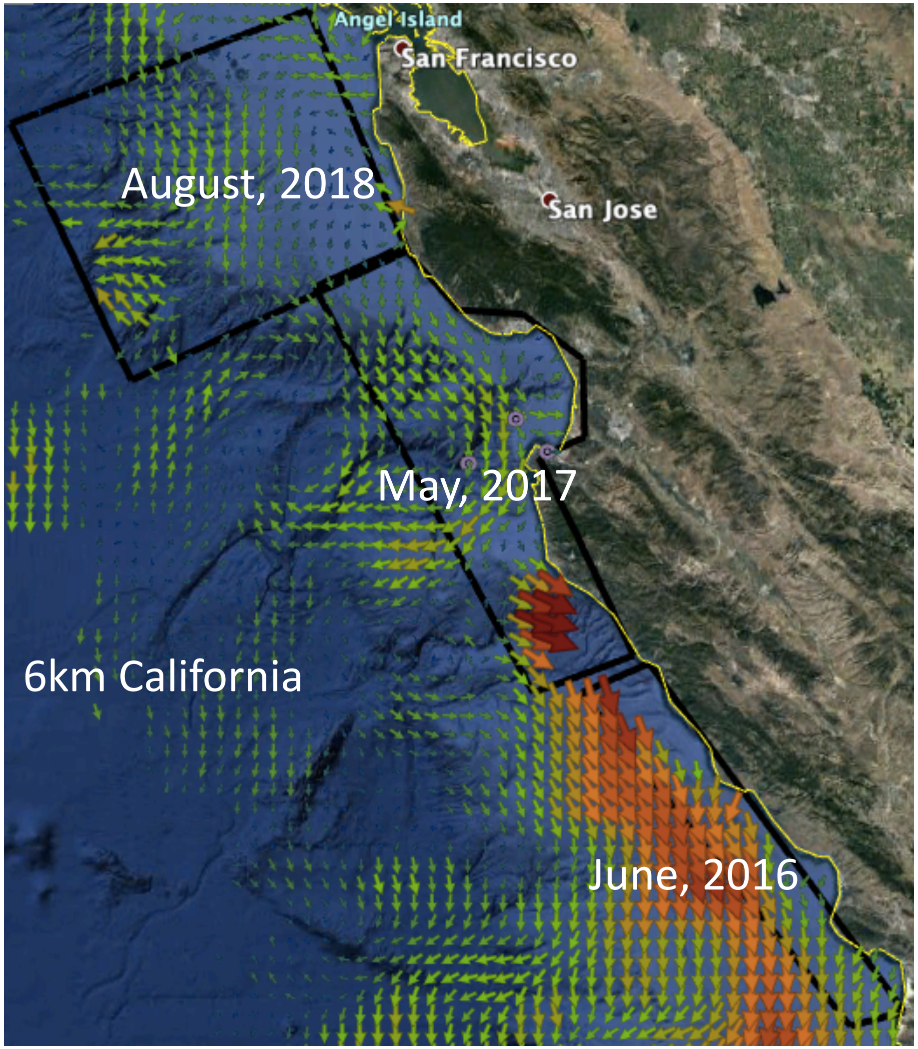
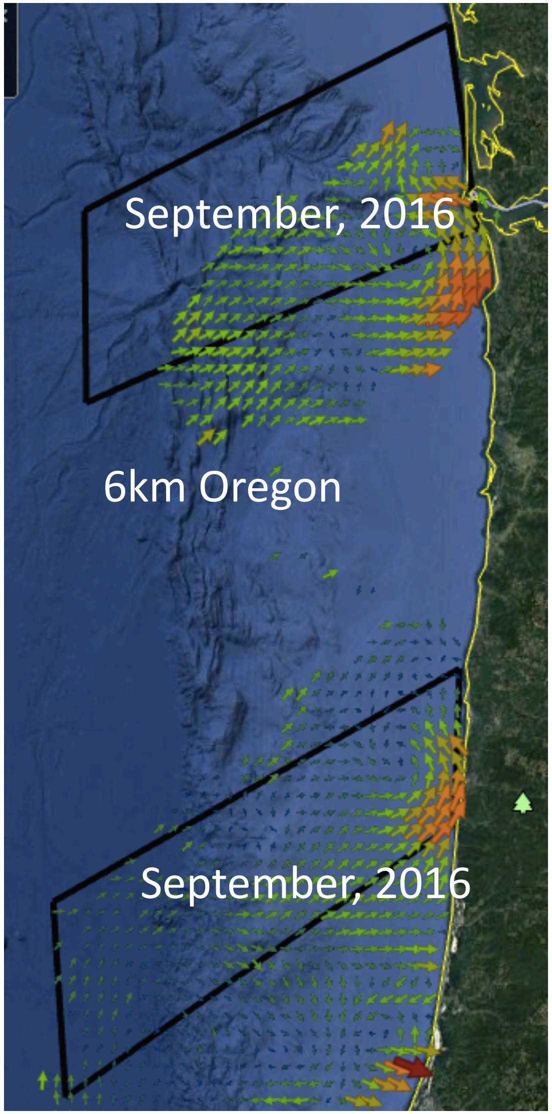
Institut fur Wasserbau und Wasserwirtschaft, Technische Universitat Darmstadt, Darmstadt, Germany

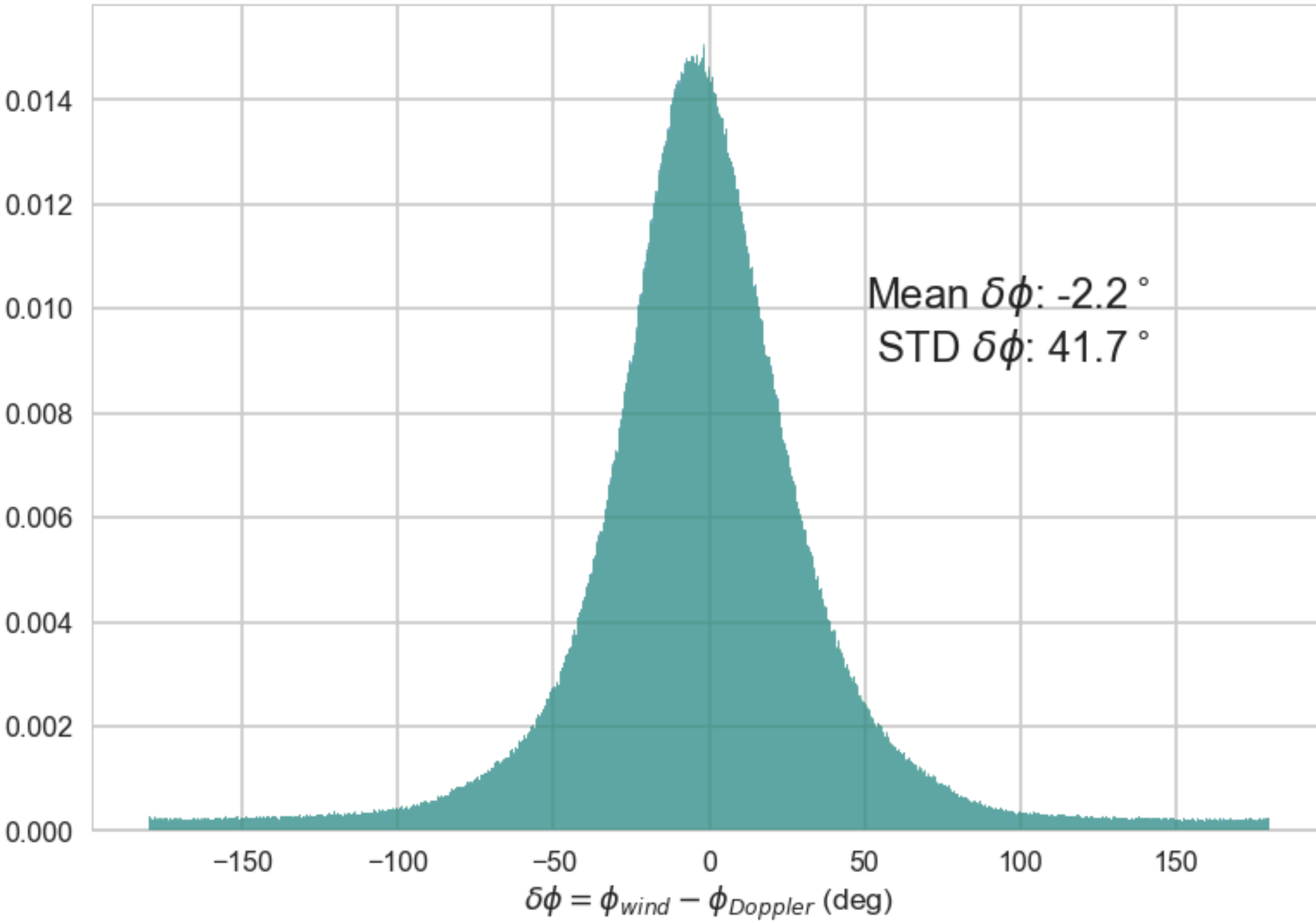
DopplerScatt-HF Radar Sites

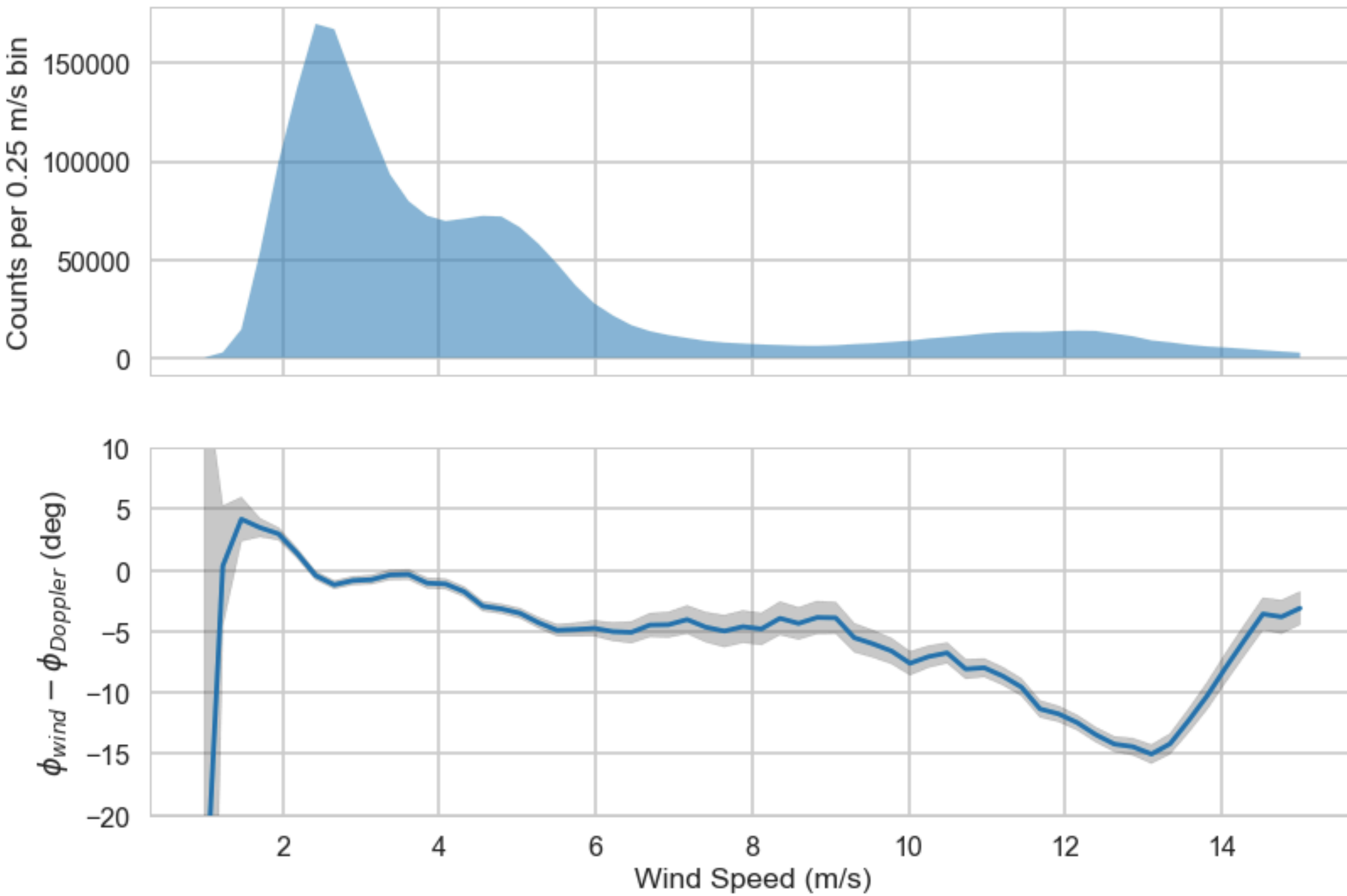




Wind vs Doppler Direction Difference

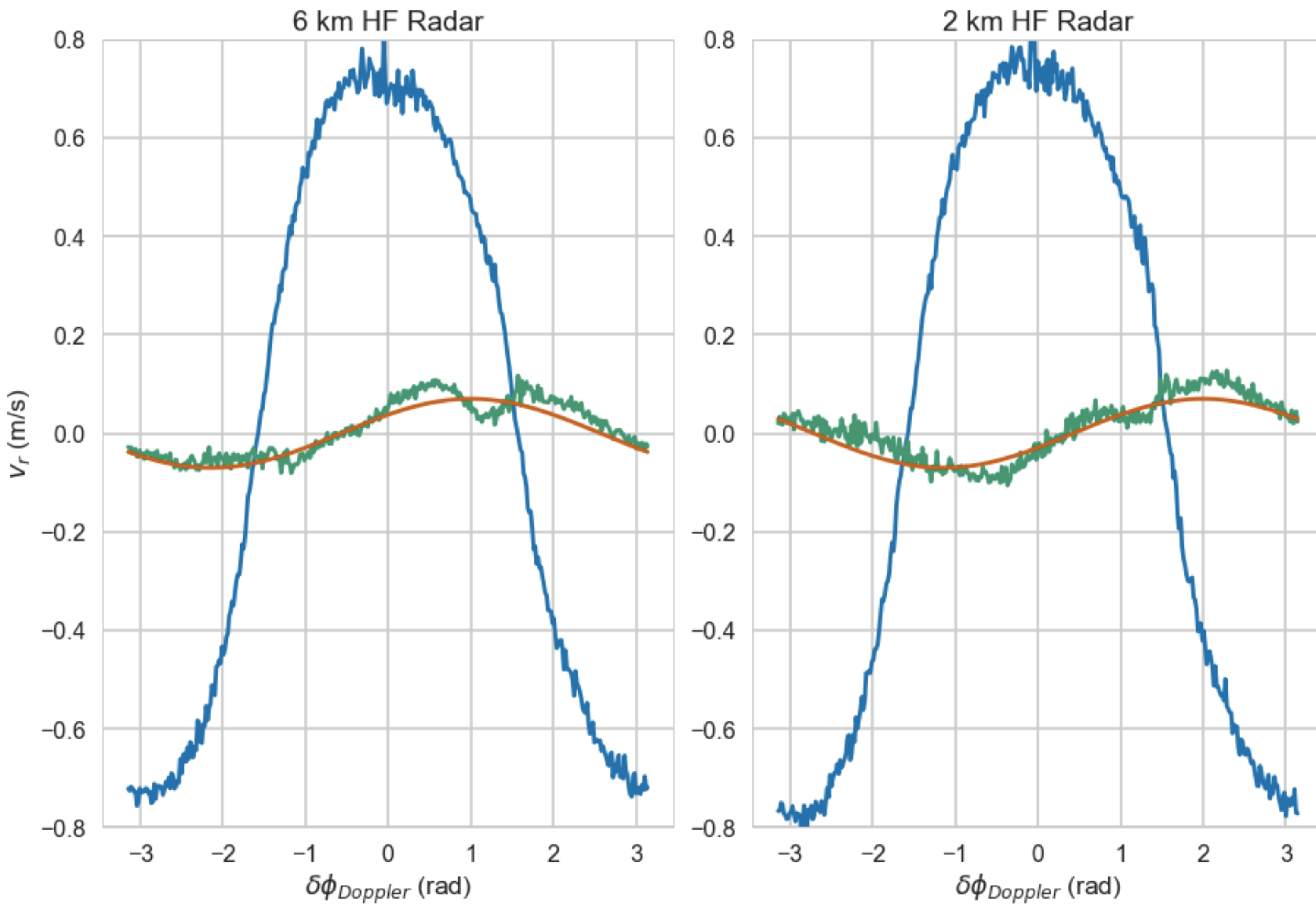
Doppler reflects velocity of 0.5 cm capillary waves.
"wind" reflects amplitude modulation of 0.5 cm capillary waves.



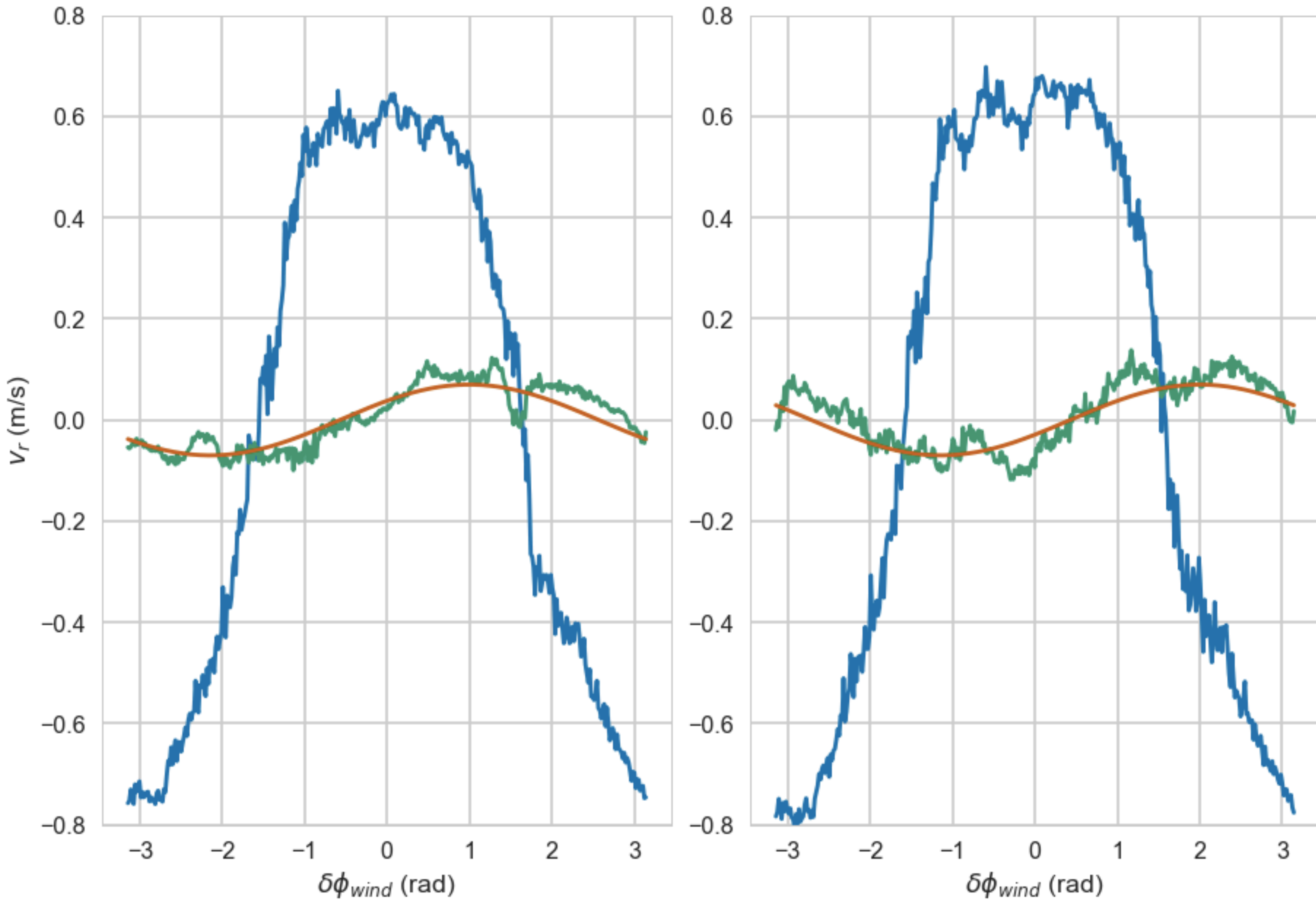


Counts per 0.25 m/s bin
150000
100000
50000
0
$\phi_{wind} - \phi_{Doppler}$ (deg)
10
5
0
−5
−10
−15
−20
2
4
6
8
10
12
14
Wind Speed (m/s)

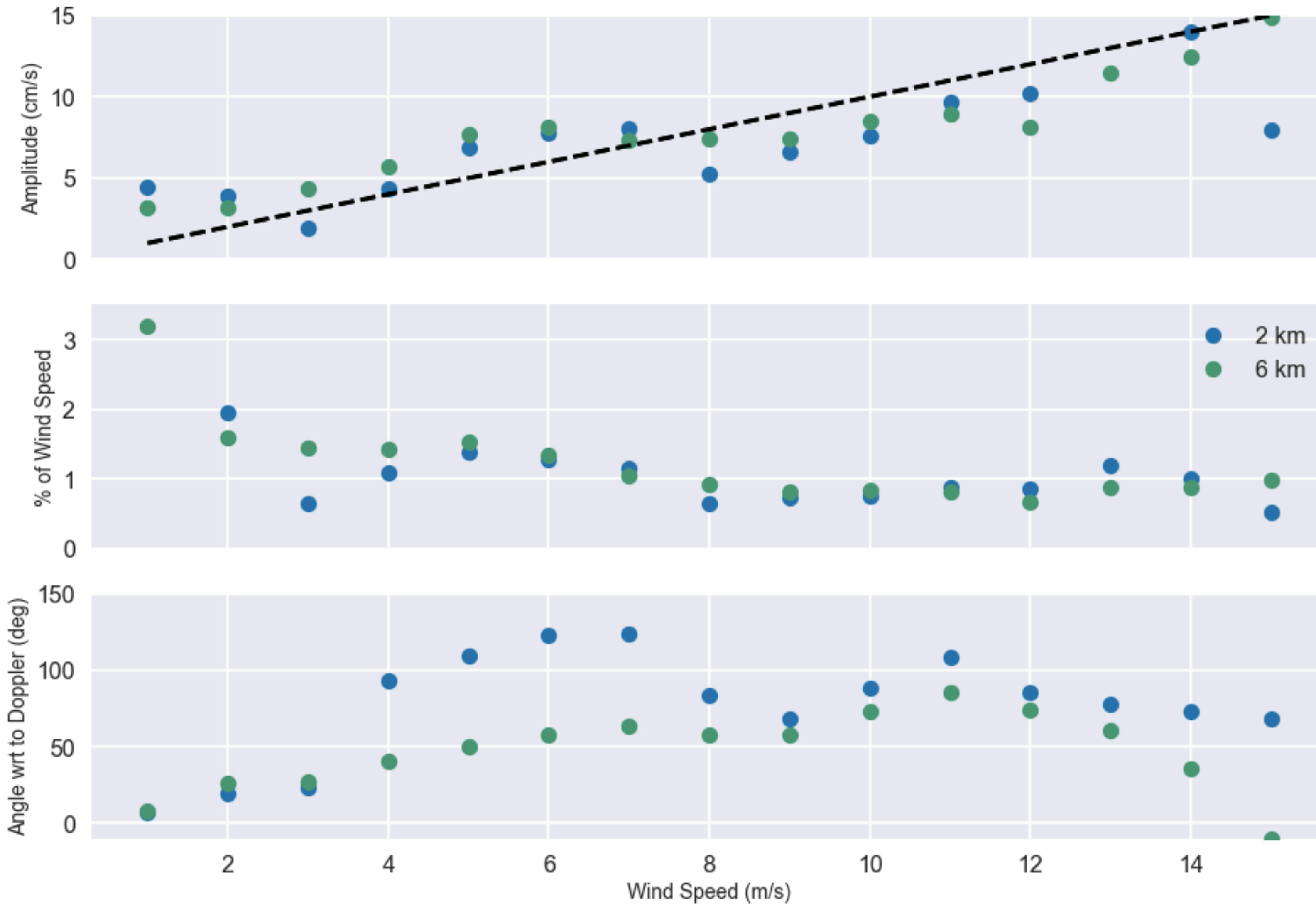
Doppler Direction Binning



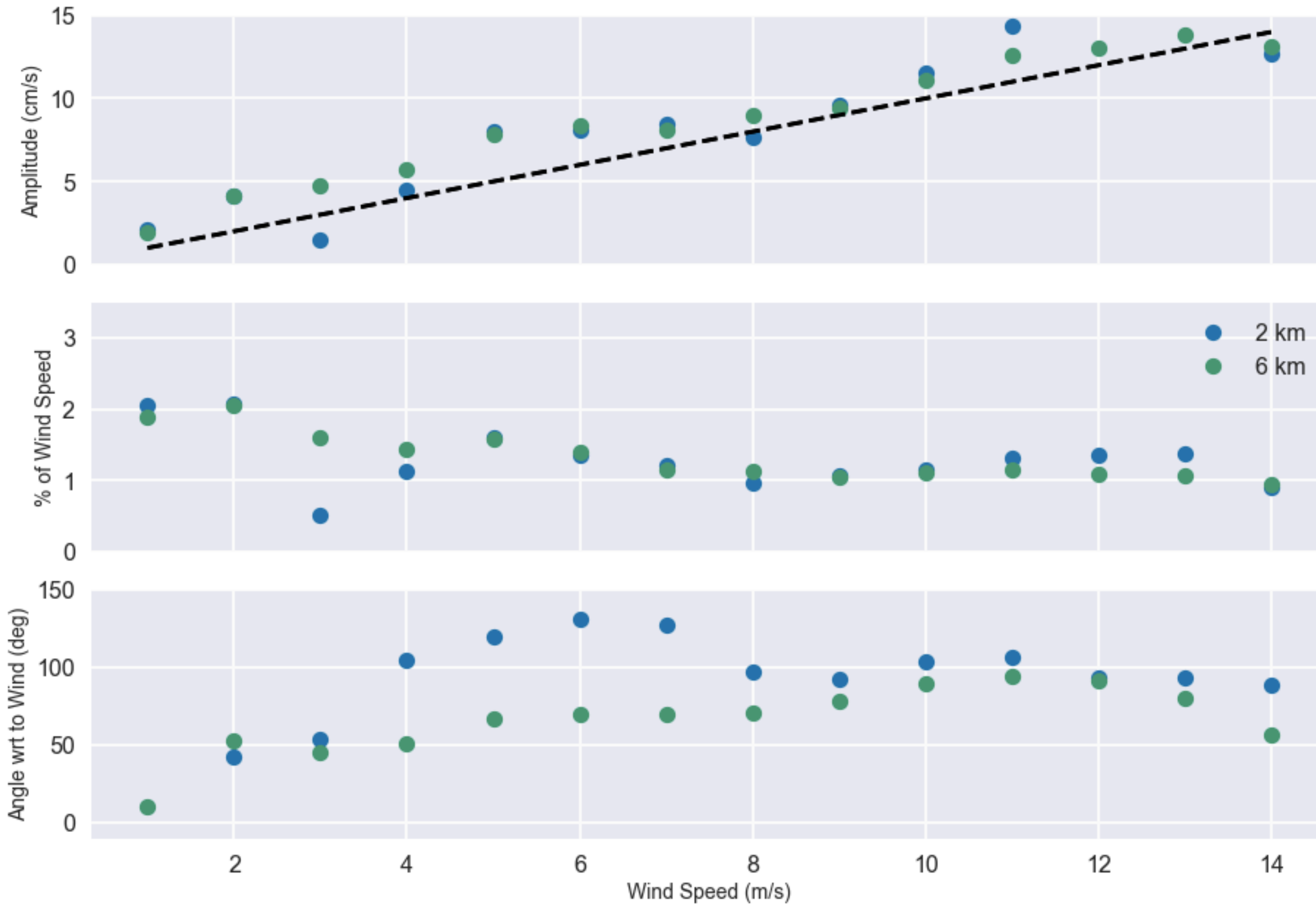
Wind Direction Binning



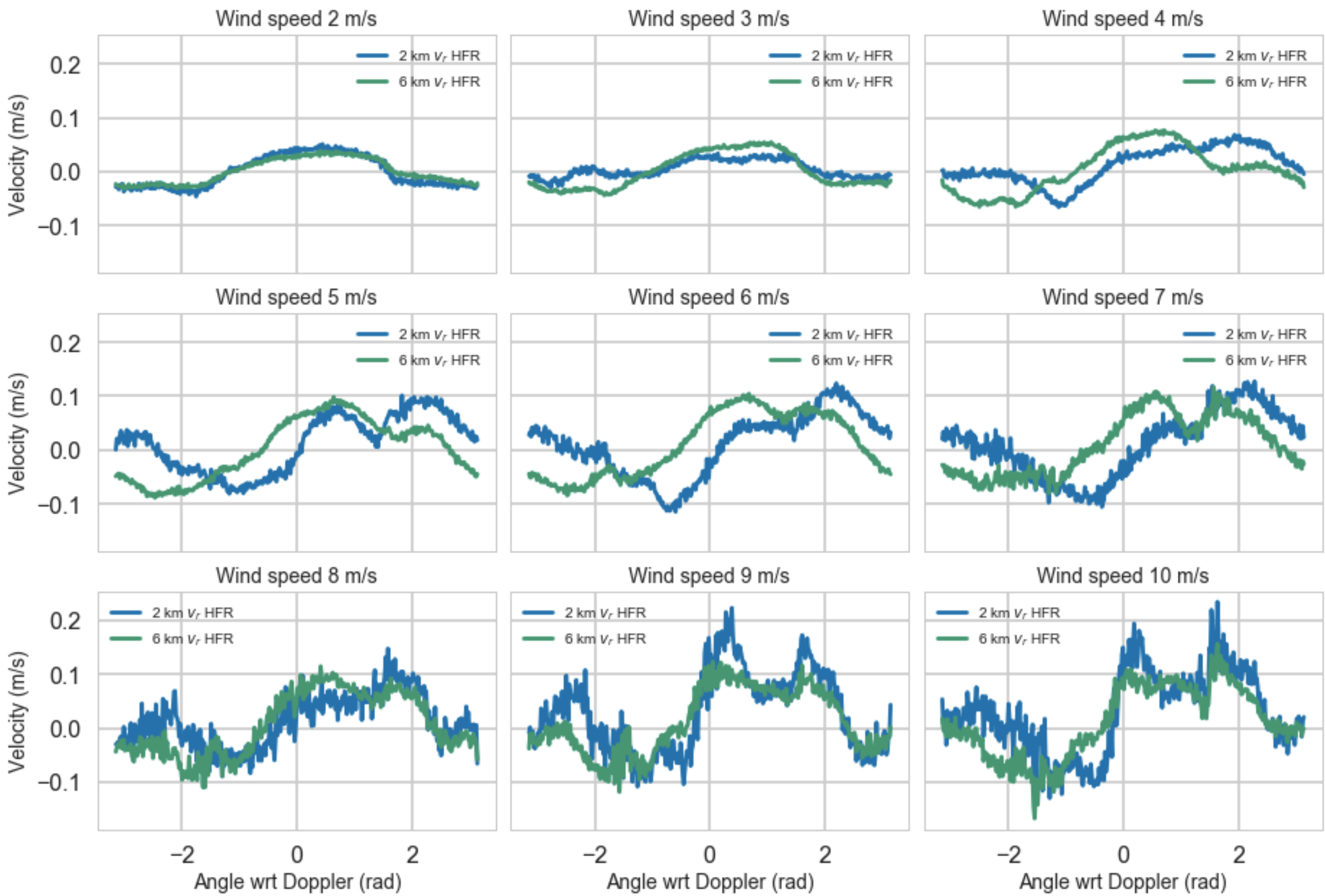
Wind Drift Wind Speed Dependence
Doppler Directions



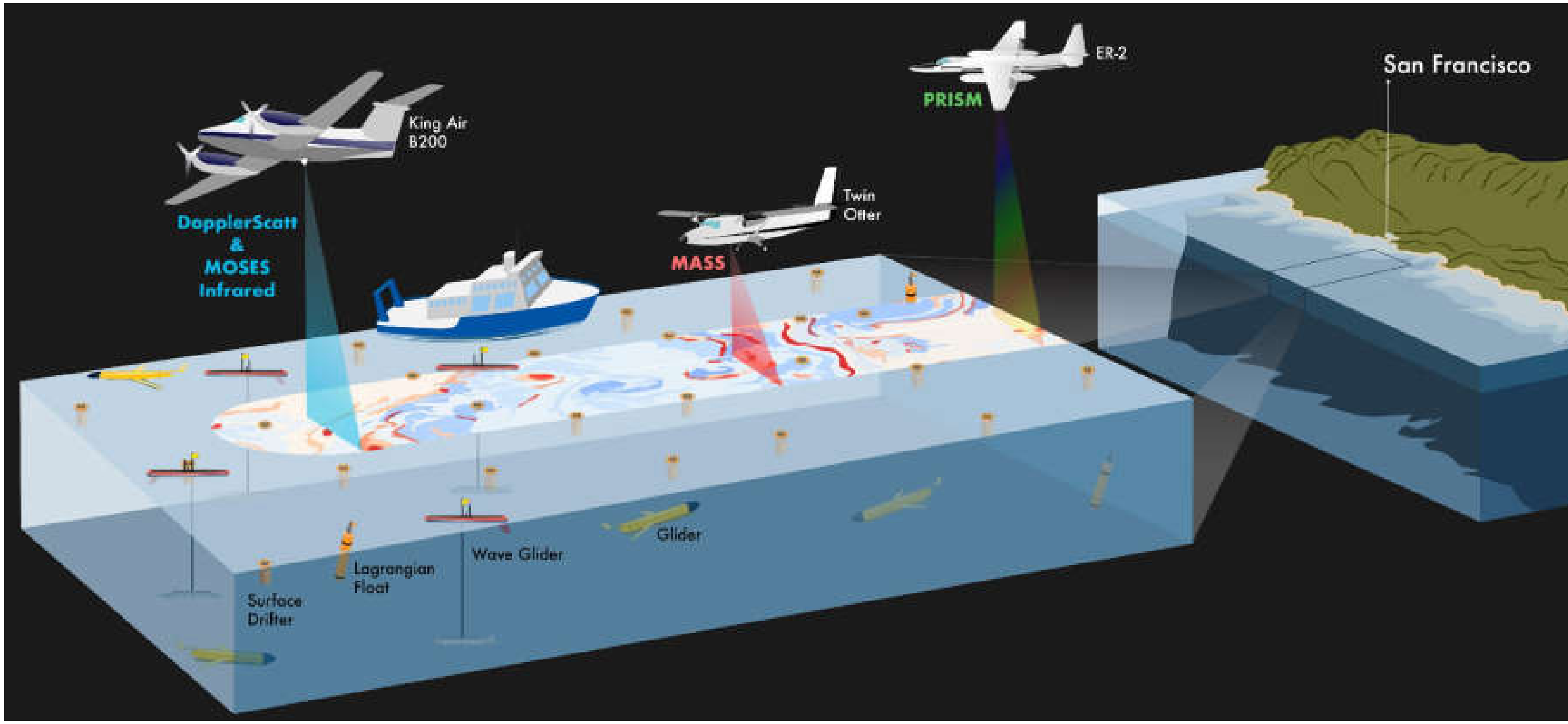
Wind Drift Wind Speed Dependence Wind Directions



HF Radar Radial Velocities Doppler Directions



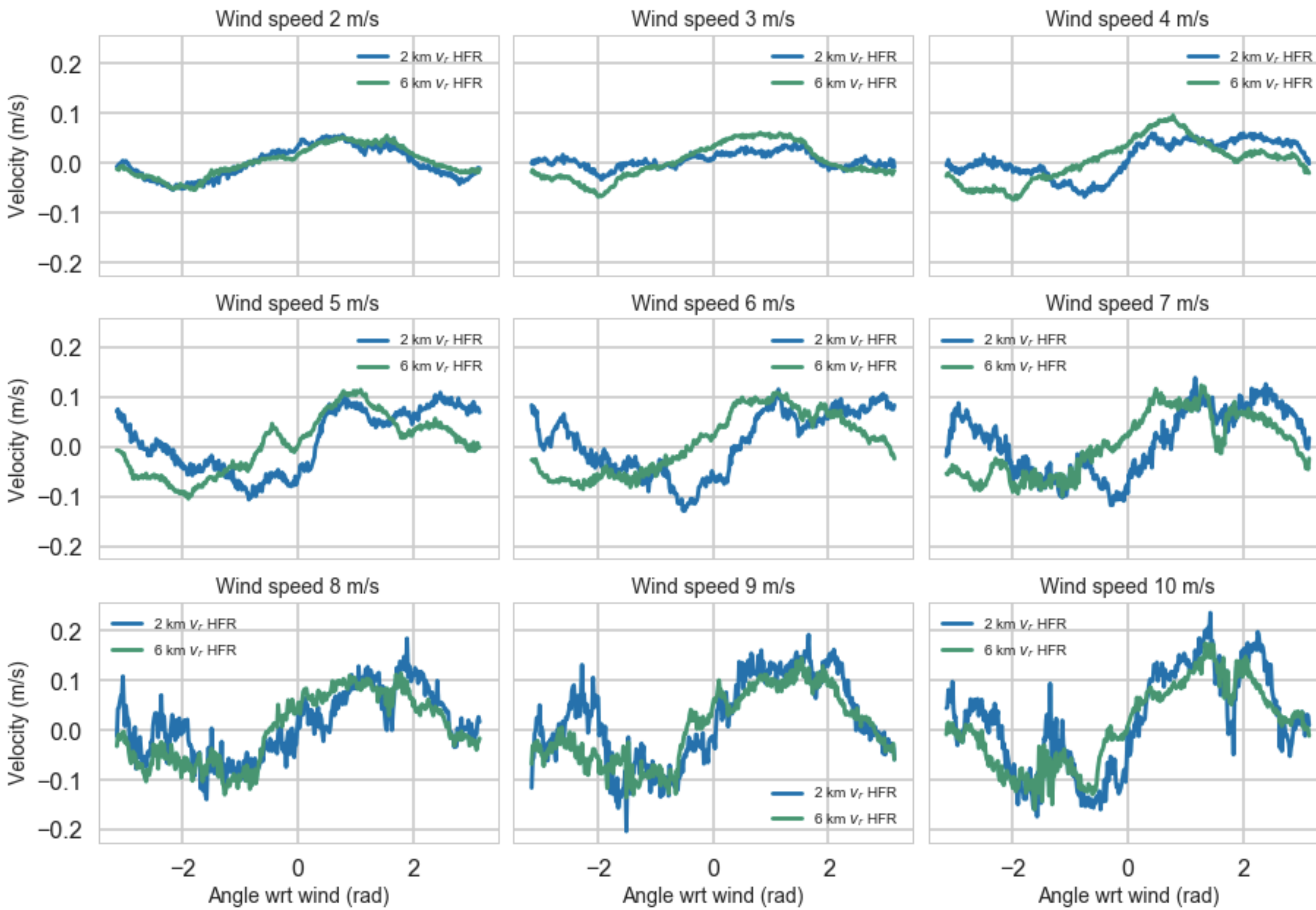
Coming up

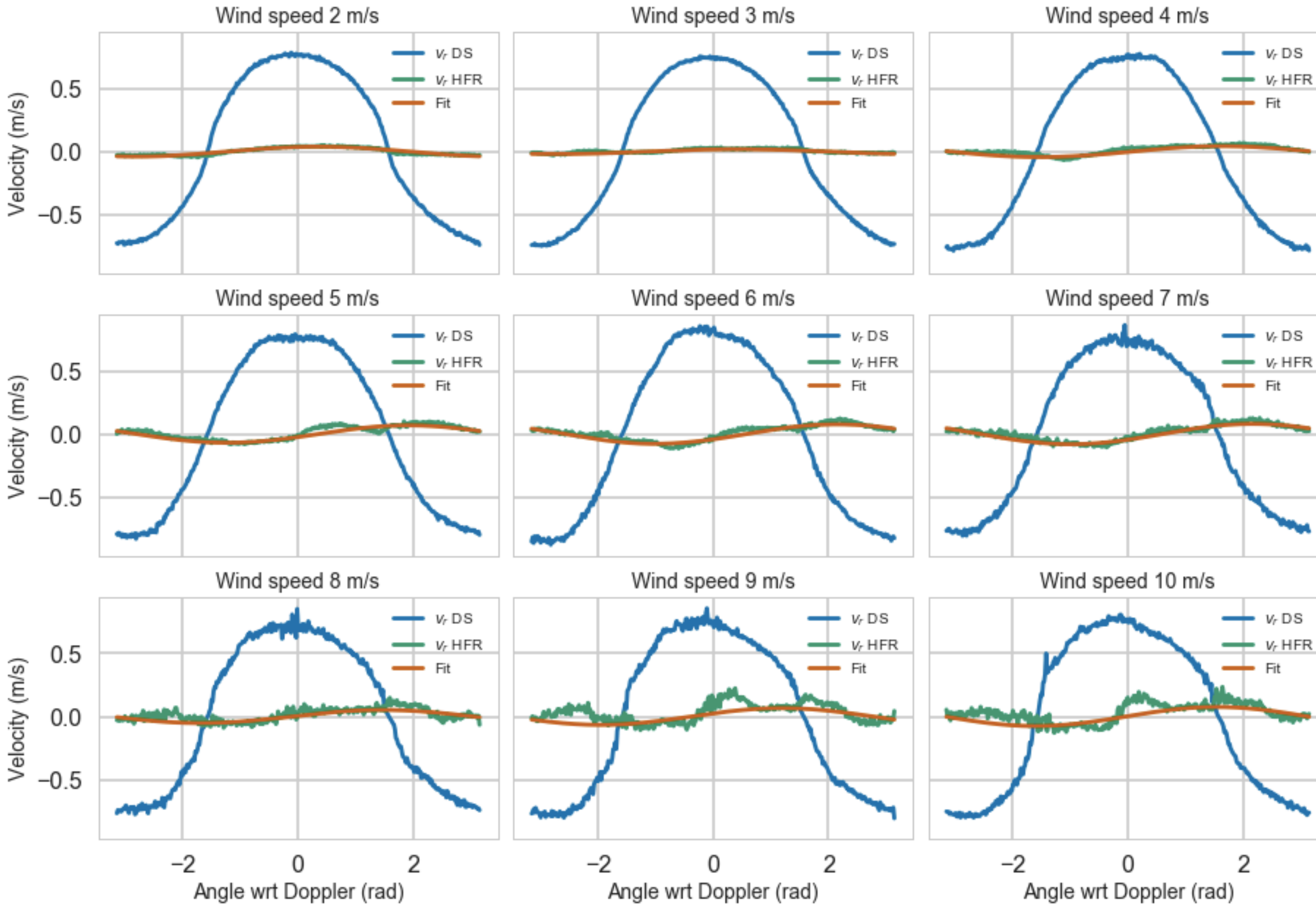


- SMODE: Sub-Mesoscale Ocean Dynamics Experiment
- NASA Earth Ventures Suborbital-3: 2019-2023
- PI Tom Farrar (WHOI)
- ASIT Tower experiment/WHOI ship experiment (?)

BACKUPS

HF Radar Radial Velocities
Wind Directions





Wind speed 2 m/s
Wind speed 3 m/s
Wind speed 4 m/s
Wind speed 5 m/s
Wind speed 6 m/s
Wind speed 7 m/s
Wind speed 8 m/s
Wind speed 9 m/s
Wind speed 10 m/s
v_r DS
v_r HFR
Fit
Velocity (m/s)
0.5
0.0
−0.5
−2
0
2
Angle wrt Doppler (rad)