Accuracy of surface current velocity measurements obtained from HF radar along the east coast of Korea

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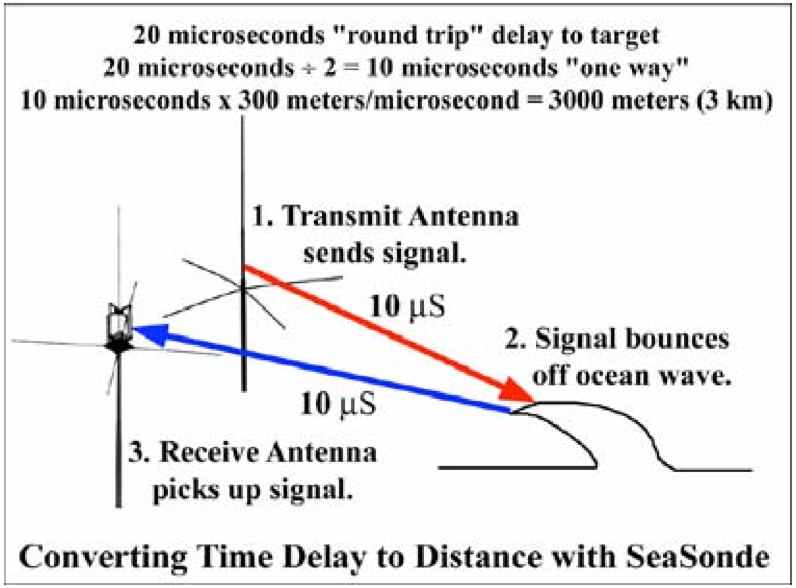
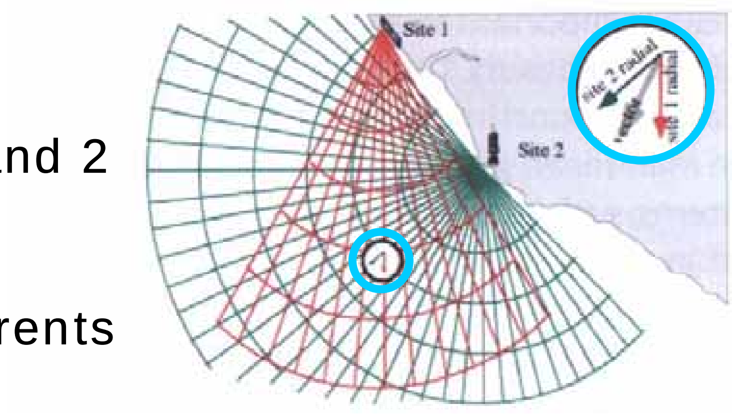
Introduction - HF radar measurement



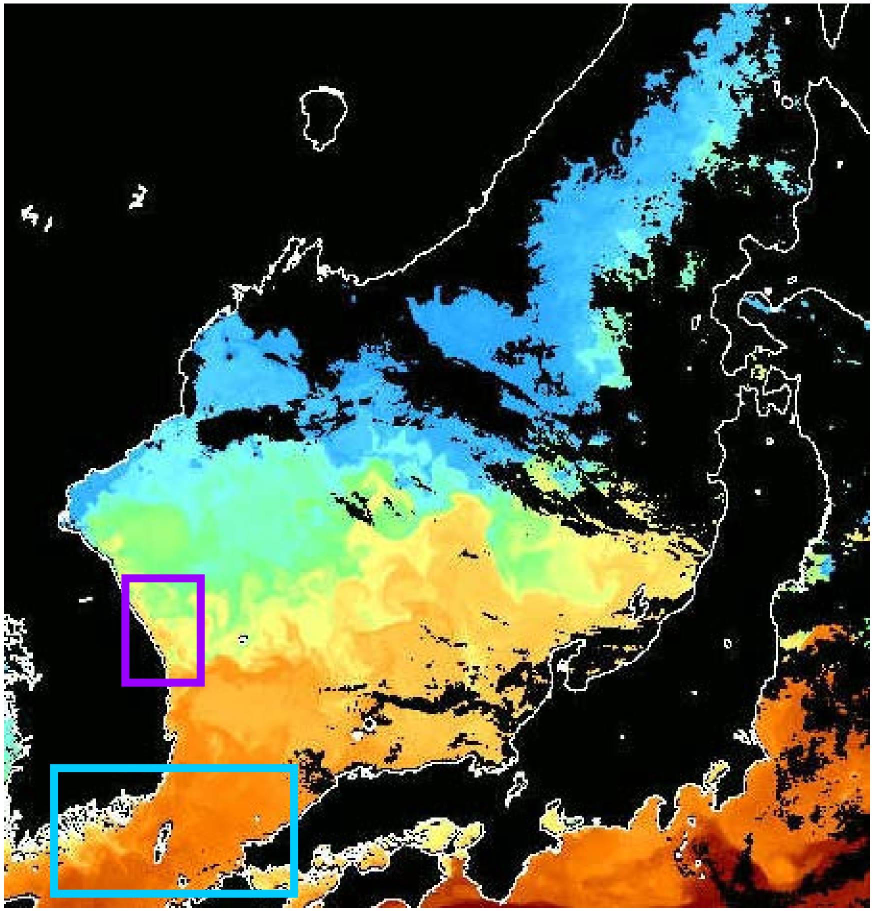
Converting Time Delay to Distance with SeaSonde

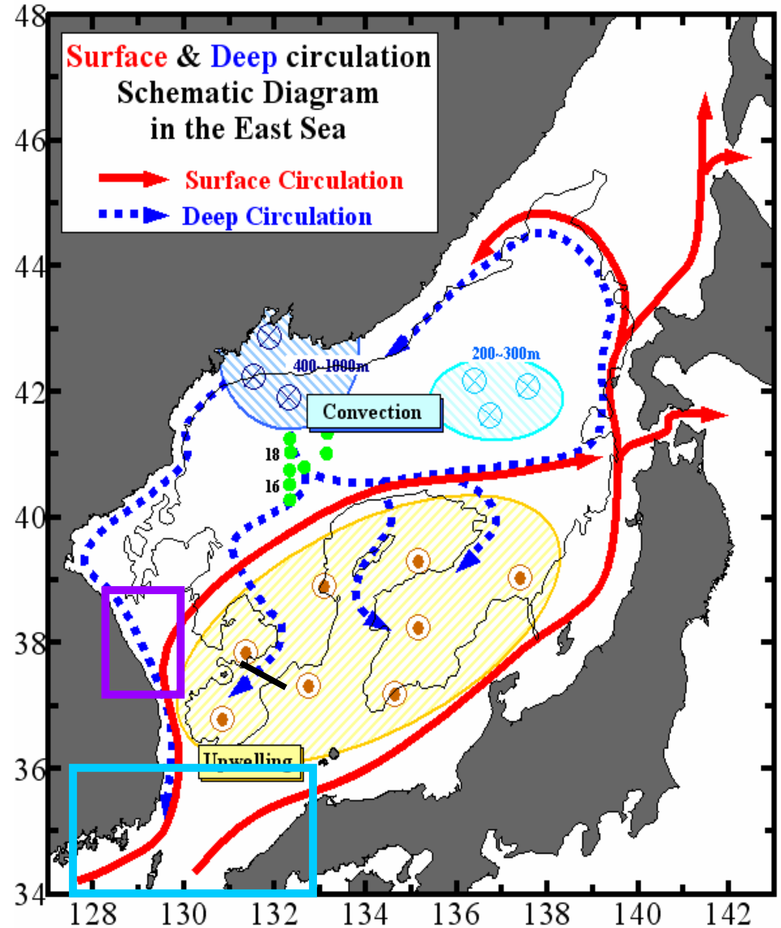
Radar measures the **range**, **bearing**, and **speed** of a target.

Where radial currents from Site 1 and 2 overlap (e.g.,), the resultant vector provides both speed and direction of the currents



Introduction – East/Japan Sea





- Inflow through the Korea/Tsushima Strait
- East Korea Warm Current (EKWC) and its separation position

Introduction – Accuracy of HF radar measurement

Accuracy

Typical RMS error: 7 cm/s

Reference	RMS error (cm/s)	location
Emery et al., 2004	7~19	Along the California coast
Yoshikawa et al., 2006	6.62~11.3	Korea/Tsushima Strait
Chapman and Graber, 1997	~ 15	Along the North Carolina Coast

Objectives

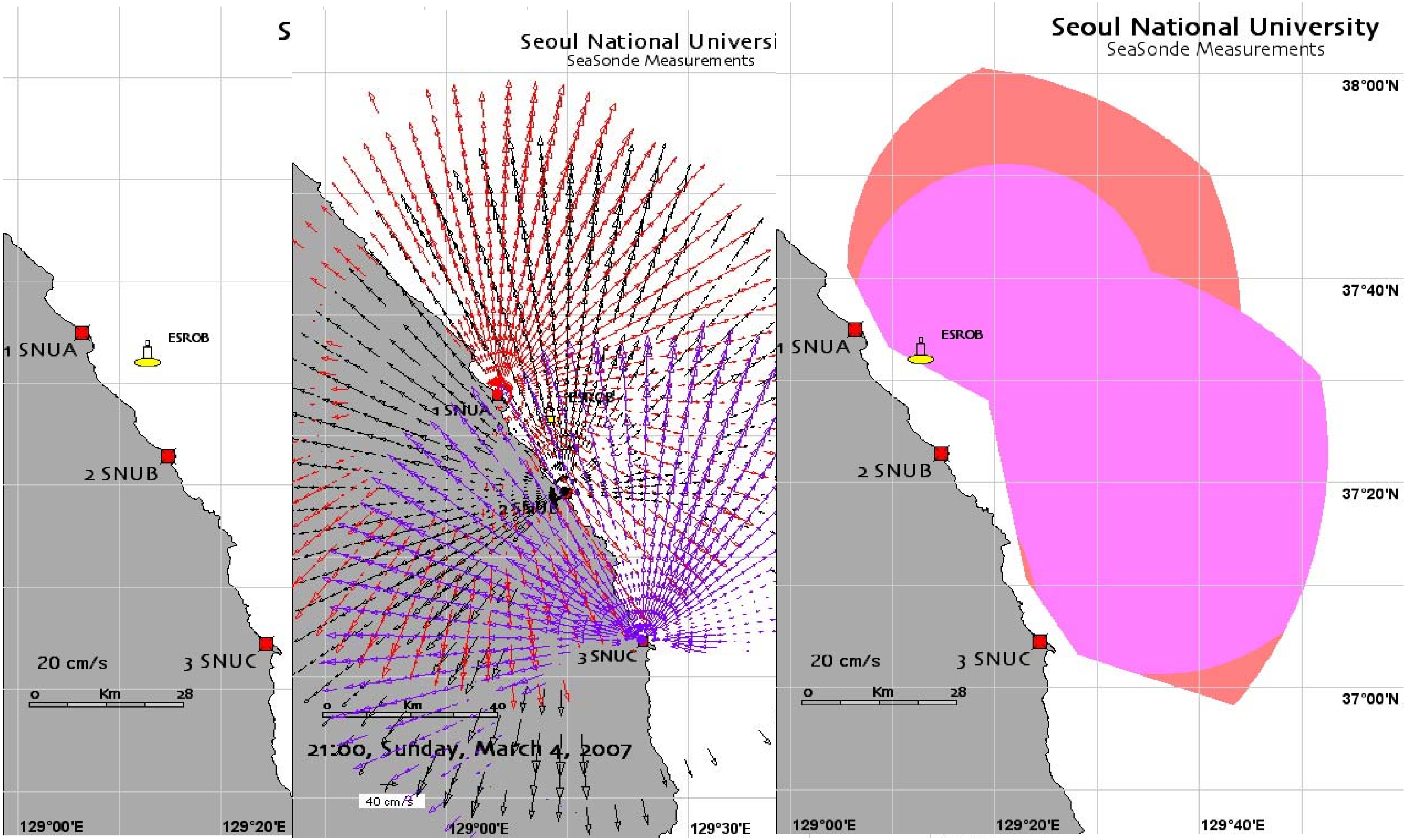
- To compare surface current velocity from HF radar measurement with *in situ* measurement

- To evaluate the accuracy of the HF radar measurement

- To discuss the source of error

Contents

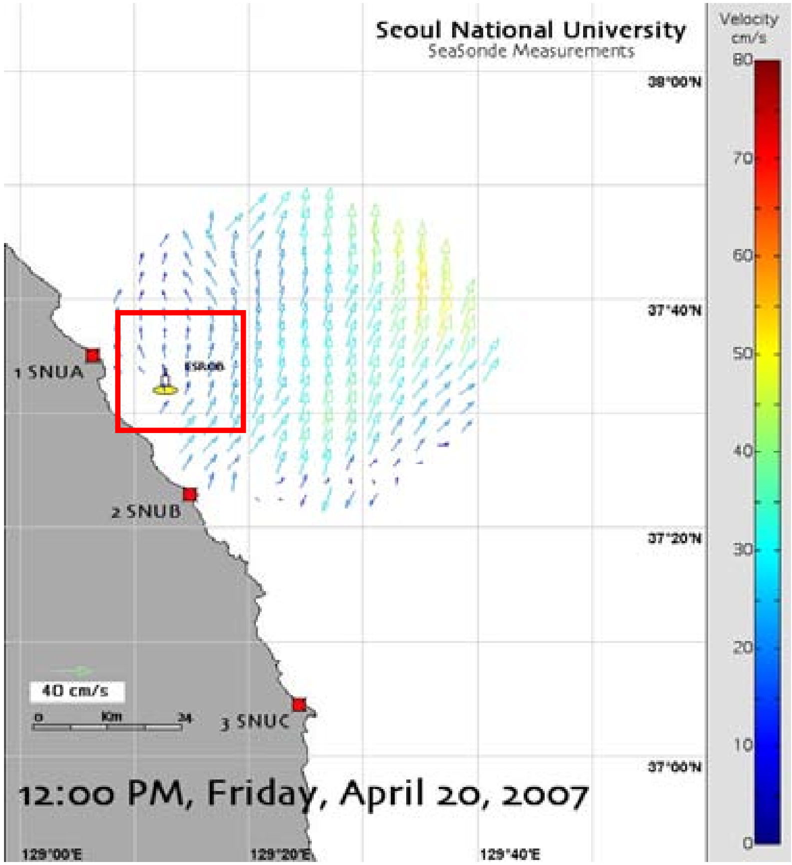
HF radar measurement



HF radar measurement

- Frequency: ~ 13 MHz
- Range: ~ 70 Km
- Resolution: ~ 3 Km
- Temporal interval: hourly

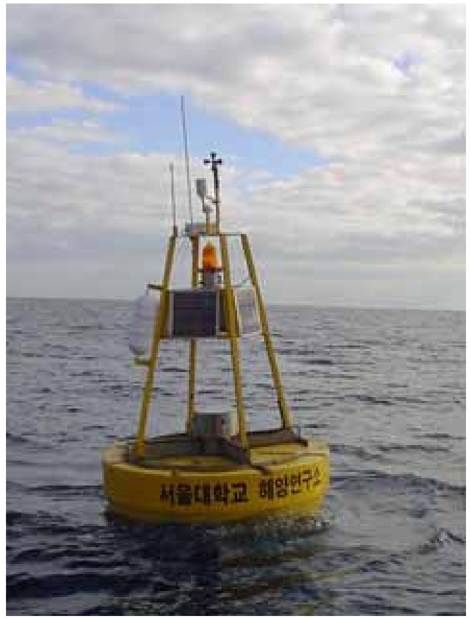
Surface current velocity vectors using site 1 and site 2
for three months
from April to June, 2007

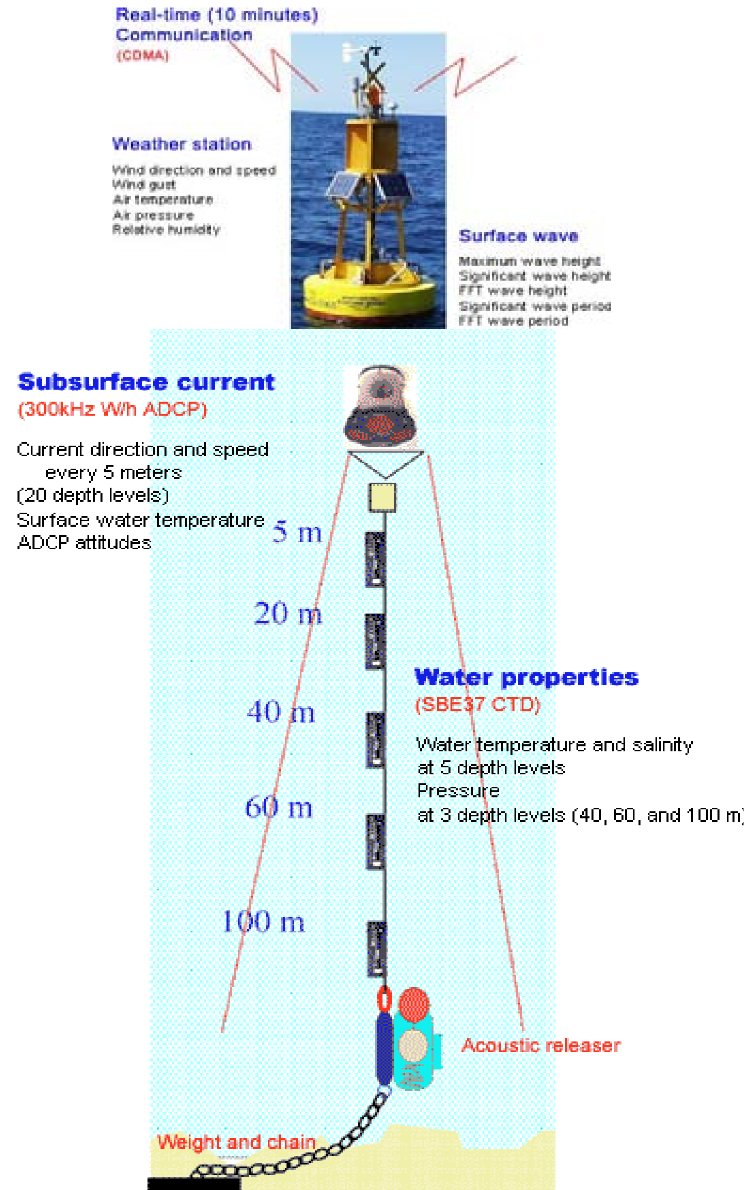


In Situ measurement

ESROB

East **S**ea
Real-time
Ocean
monitoring
Buoy

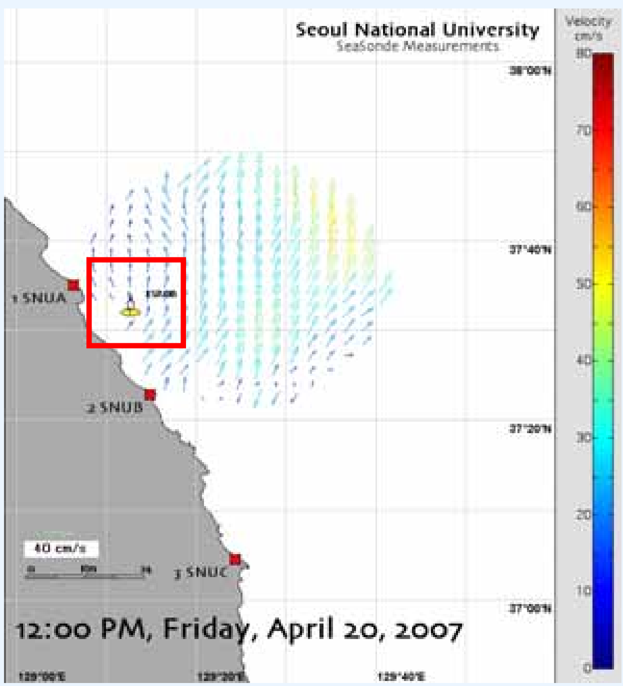




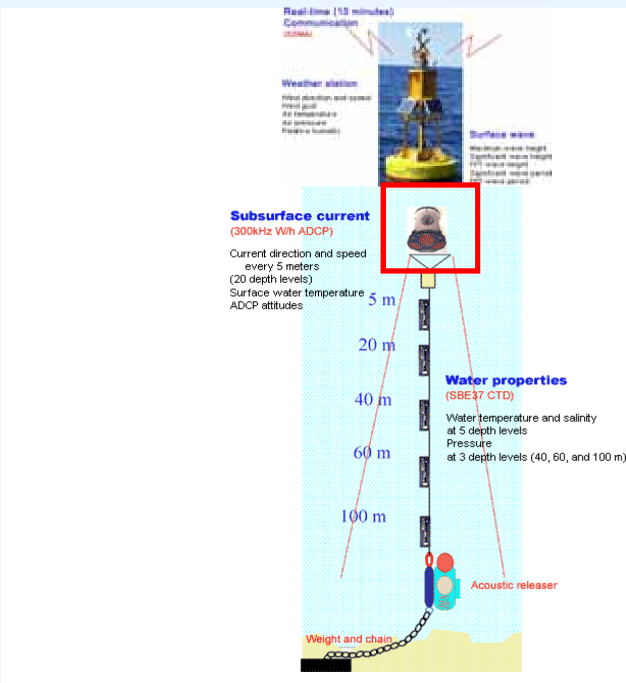
- Wind speed & direction
- Air pressure, humidity
- Down-looking ADCP(300kHz)
- SBE37(T,P,C) 6EA

Comparison of the two measurements

HF radar measurements



In Situ measurements



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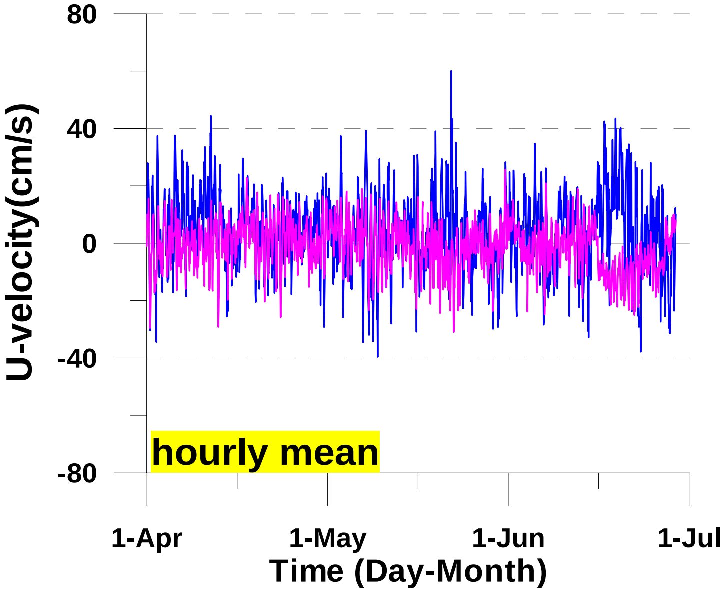
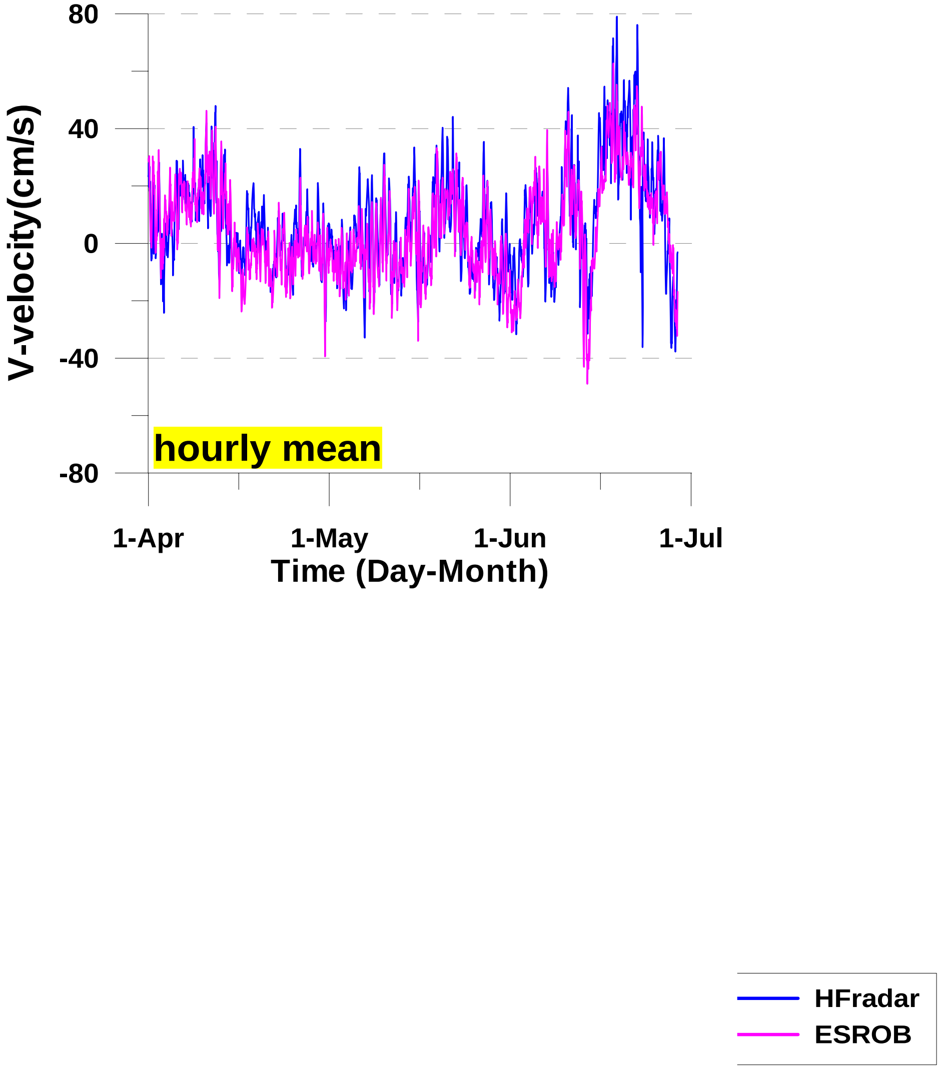
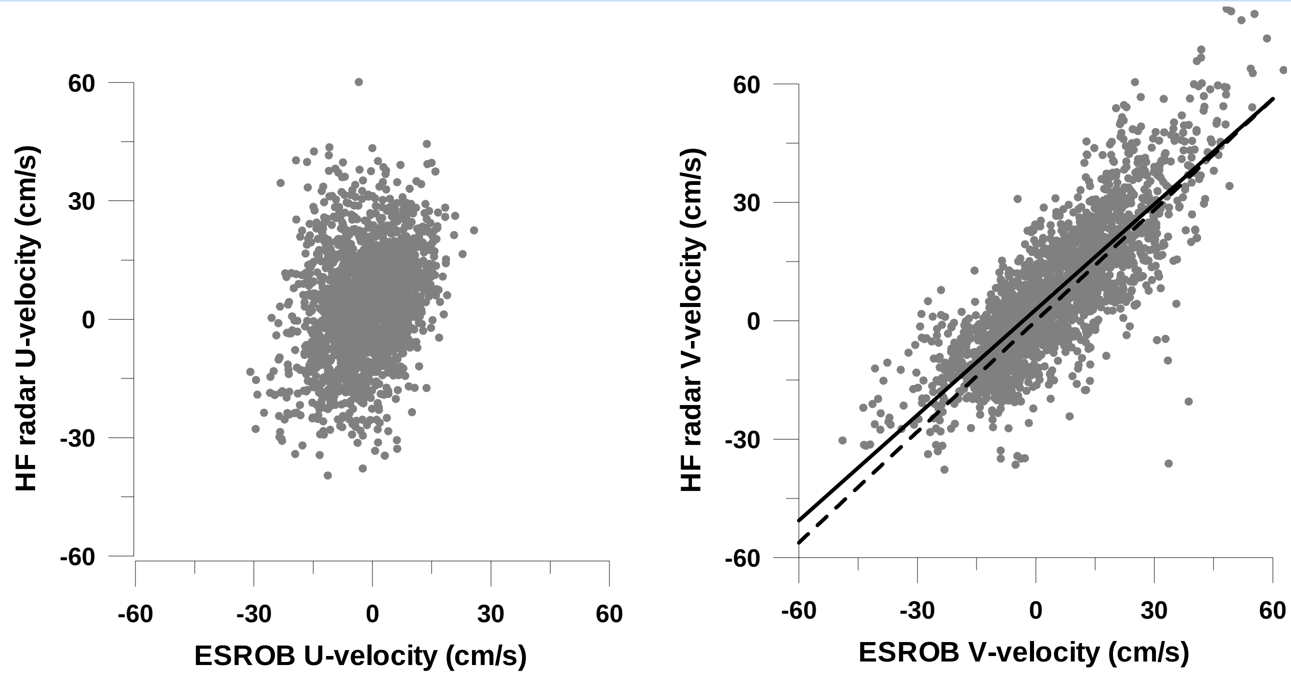




Comparison of the two measurements

hourly mean

Regression line
Y=AX+B (solid line)
Y=A`X (dotted line)

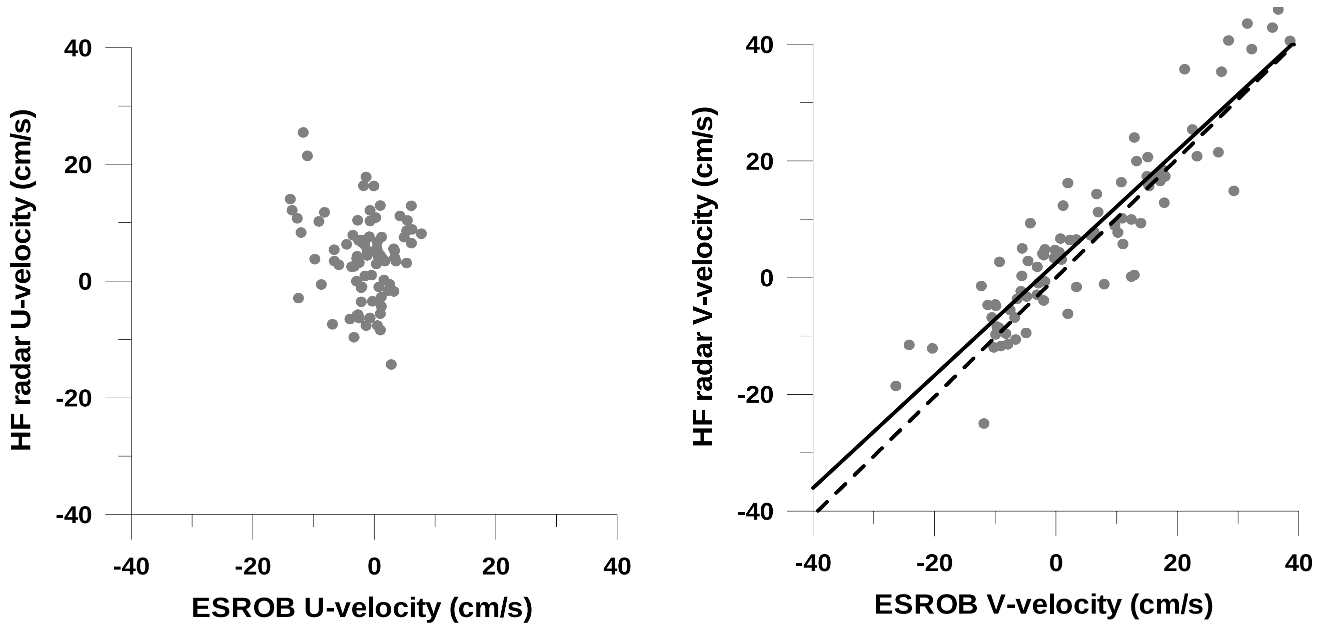


	U- velocity	V-velocity
Number of samples	2069	2069
Regression coefficient, A	0.48	0.89
Regression coefficient, B	4.66	2.83
Regression coefficient, A’	0.39	0.94
Correlation coefficient	0.30	0.81
RMS error (cm/s)	12.73	10.36

Comparison of the two measurements

daily mean

Regression line
Y=AX+B (solid line)
Y=A`X (dotted line)



	U- velocity	V-velocity
Number of samples	86	86
Regression coefficient, A	-0.26	0.96
Regression coefficient, B	3.62	2.52
Regression coefficient, A’	-0.47	1.02
Correlation coefficient	-0.17	0.91
RMS error (cm/s)	7.09	6.2

Comparison of the two measurements

Why do U-velocities show large difference, while V-velocities show small difference?

$$\sigma^2_{diff} = \boxed{\sigma^2_{HF}} + \boxed{\sigma^2_{in\ situ}} + \boxed{\sigma^2_{physics}}$$

Chapman et al., 1997

HF radar measurements

- Near surface currents (~ 1m)
- Averaged over 3 km square

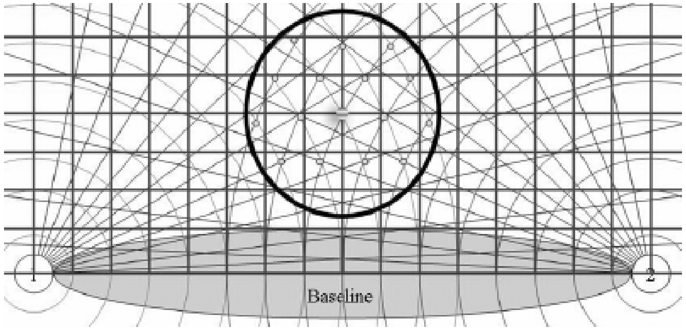
***In Situ* measurements**

- Typically greater than the HF radar's effective depth
- At essentially a single point in space

Discussion

- **GDOP (Geometrical Dilution of precision)**

  - Coefficient of uncertainty that characterizes the effect of the geometry of the coupled radar system on the measurement and position determination errors
  - A low GDOP corresponds to an optical geometric configuration of radar stations



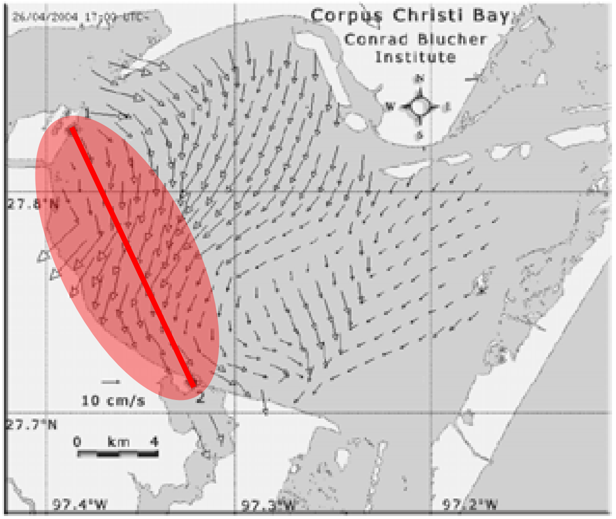
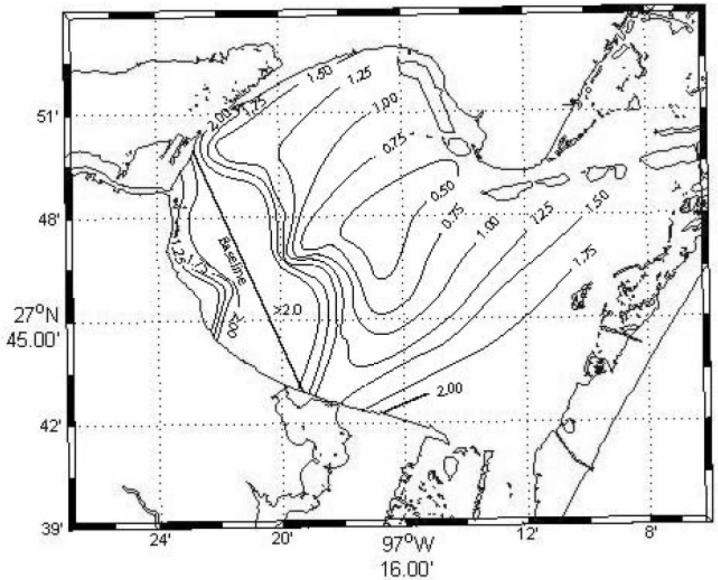
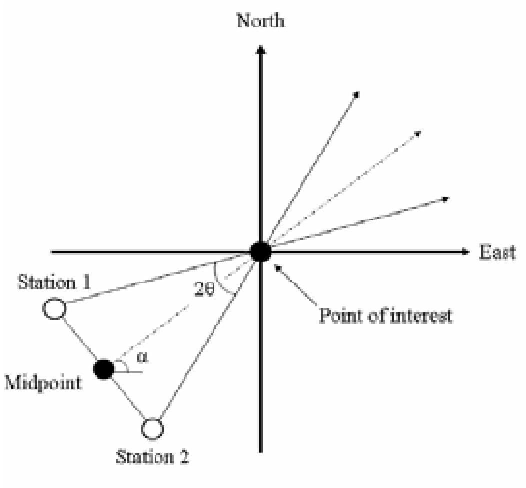


Figure 1. Total surface current vector map of Corpus Christi Bay for April 04, 2004 17:00 UTC unedited for GDOP.



Trujillo et al., 2004

Discussion



$$\sigma_n = \left[2 \left(\frac{\sin^2(\alpha)\sin^2(\theta) + \cos^2(\alpha)\cos^2(\theta)}{\sin^2(2\theta)} \right) \right]^{\frac{1}{2}} \sigma$$

$$\sigma_e = \left[2 \left(\frac{\cos^2(\alpha)\sin^2(\theta) + \cos^2(\alpha)\sin^2(\theta)}{\sin^2(2\theta)} \right) \right]^{\frac{1}{2}} \sigma$$

Chapman et al., 1997

α : the mean look angle
θ : half of the angle of the intersecting beams, and
σ : the root mean square differences in the current estimates

$$\alpha = 27.31^\circ$$

$$\theta = 60.31^\circ$$

$$\sigma_n = 0.98 \times \sigma$$

$$\sigma_e = 1.79 \times \sigma$$

North GDOP: 0.98

East GDOP: 1.79

Summary

- **Objectives**

  - To compare surface current velocity from HF radar measurement with *in situ* measurement
  - To evaluate the accuracy of the HF radar measurement
  - To discuss the source of error

- **Results**

  - More low-frequency variability of the V-velocity

    High correlation coefficient for V-velocity

  - RMS error of hourly mean U-velocity and V-velocity were about 13 and 10 cm/s, respectively. RMS error of daily mean U-velocity and V-velocity were about 7 and 6 cm/s, respectively
  - High east GDOP value at the position of *in situ* measurement explained low correlation coefficient and large RMS error of U-velocity

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Thank you.

References

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- Yoshikawa, Y., A. Masuda, K. Marubayashi, M. Ishibashi, and A. Okuno (2006), On the accuracy of HF radar measurement in the Tsushima Strait, J. Geophys. Res., 111, C04009, doi:10.1029/2005JC003232.

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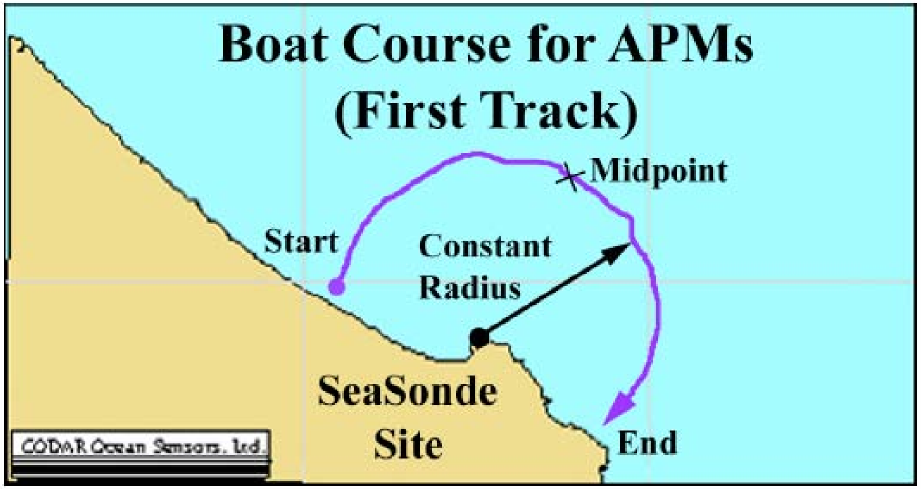
How to increase the accuracy

Antenna Pattern Measurement (APM)

Antenna patterns are often distorted when an antenna is deployed in the field. Tests indicate that the local environment, not system hardware, causes the most significant distortion of the pattern from the theoretical shape.



Sources of U-velocity difference

Spatial characteristics of U-velocity ⇨ $\sigma^2_{physics}$

if U-velocity has large spatial variability near the *in situ* measurement location

if U-velocity has large vertical shear near the *in situ* measurement location