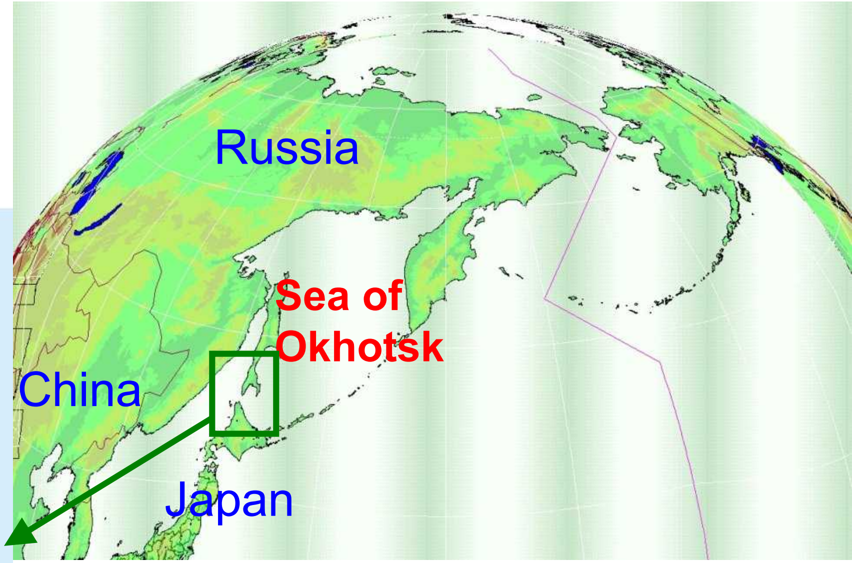
Estimation of Wind Drift Current in the Soya Strait

Wei Zhang, Naoto Ebuchi,
Yasushi Fukamachi

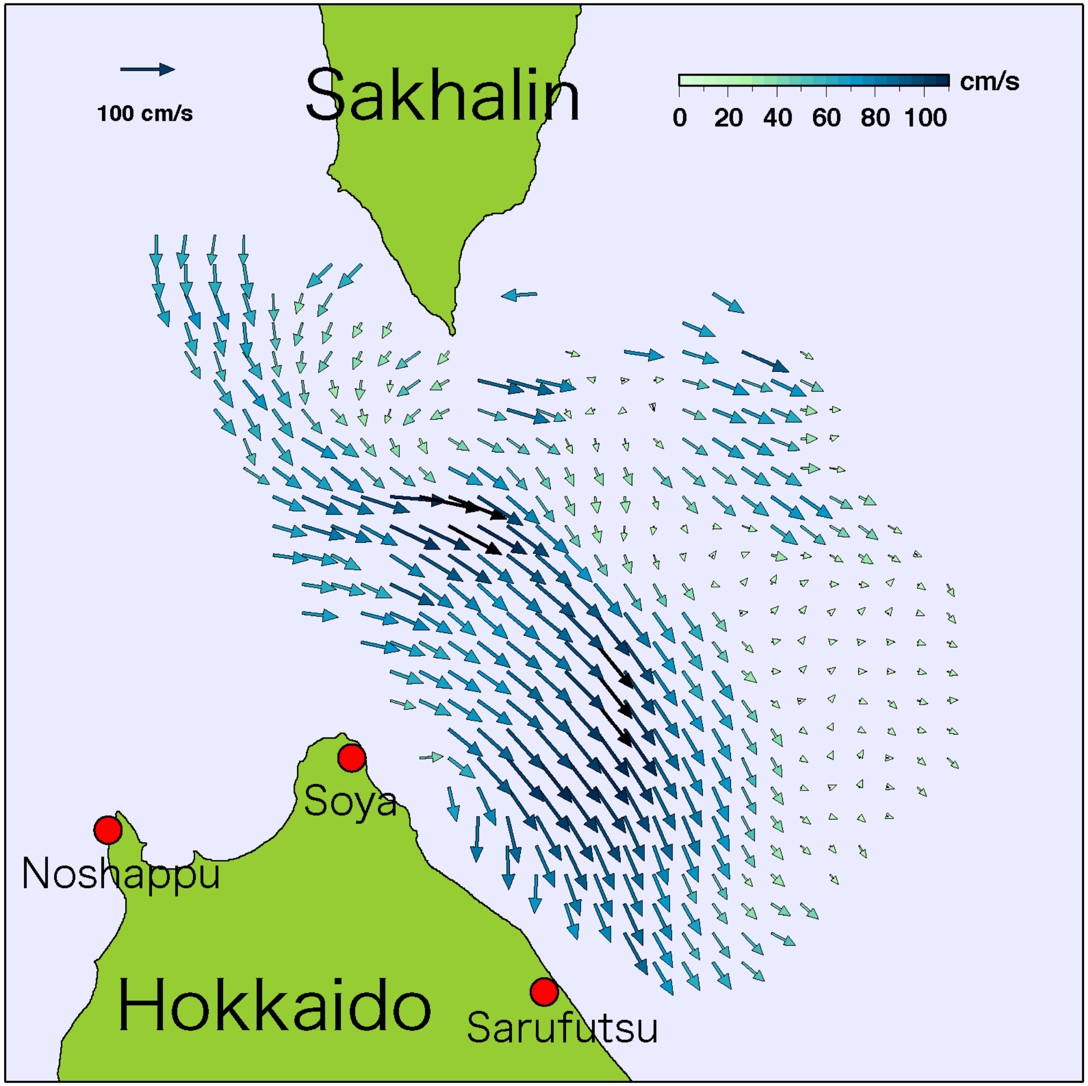
Institute of Low Temperature Science
Hokkaido University
zhangwei@lowtem.hokudai.ac.jp

The Soya Strait



- Connection of Sea of Japan Sea and Sea of Okhotsk
- Soya warm current
- Fishery

Example of HF Radar Snapshot

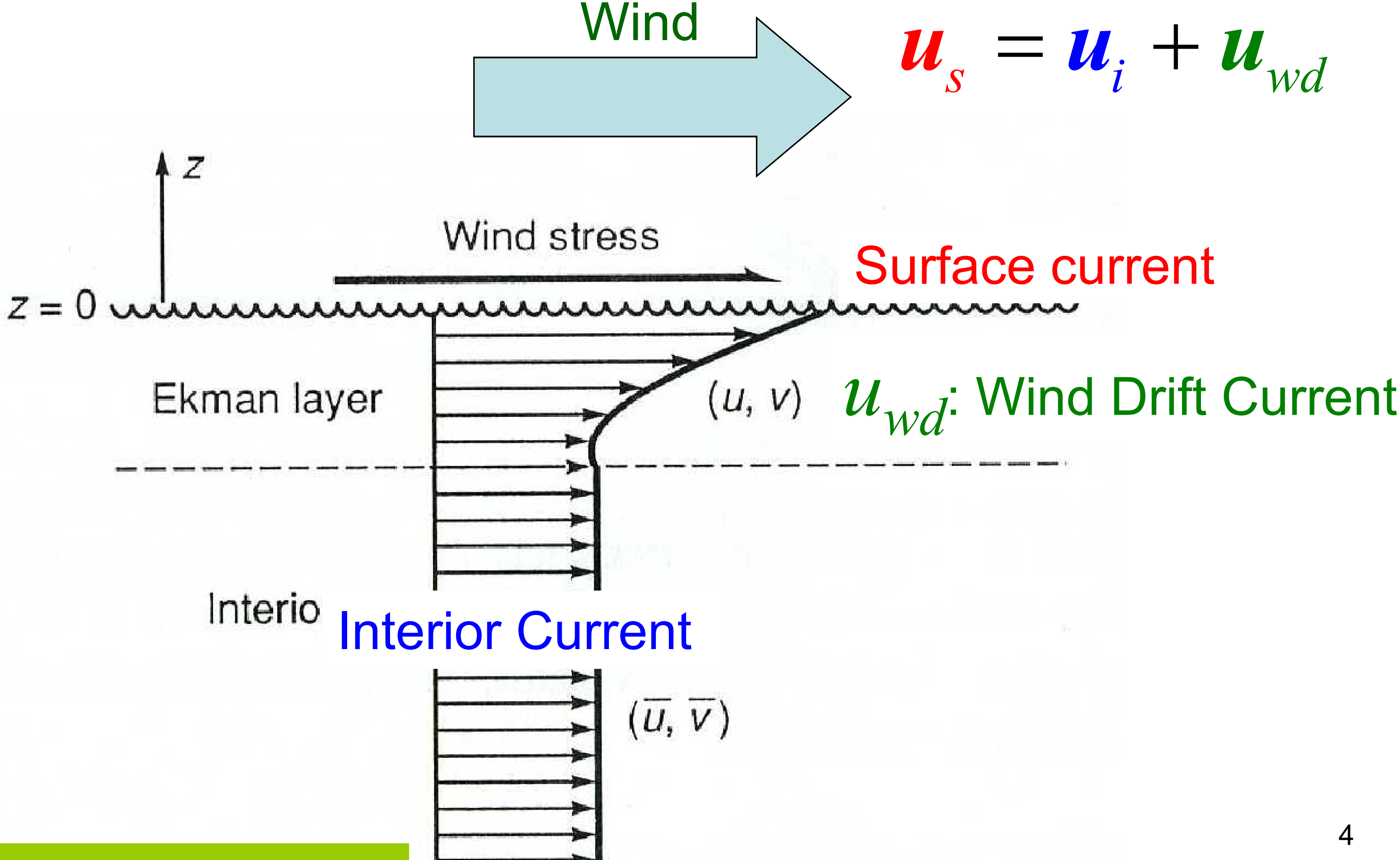


17h20m (JST)
3 Aug 2003

http://wwwoc.lowtem.hokudai.ac.jp/hf-radar/index.html

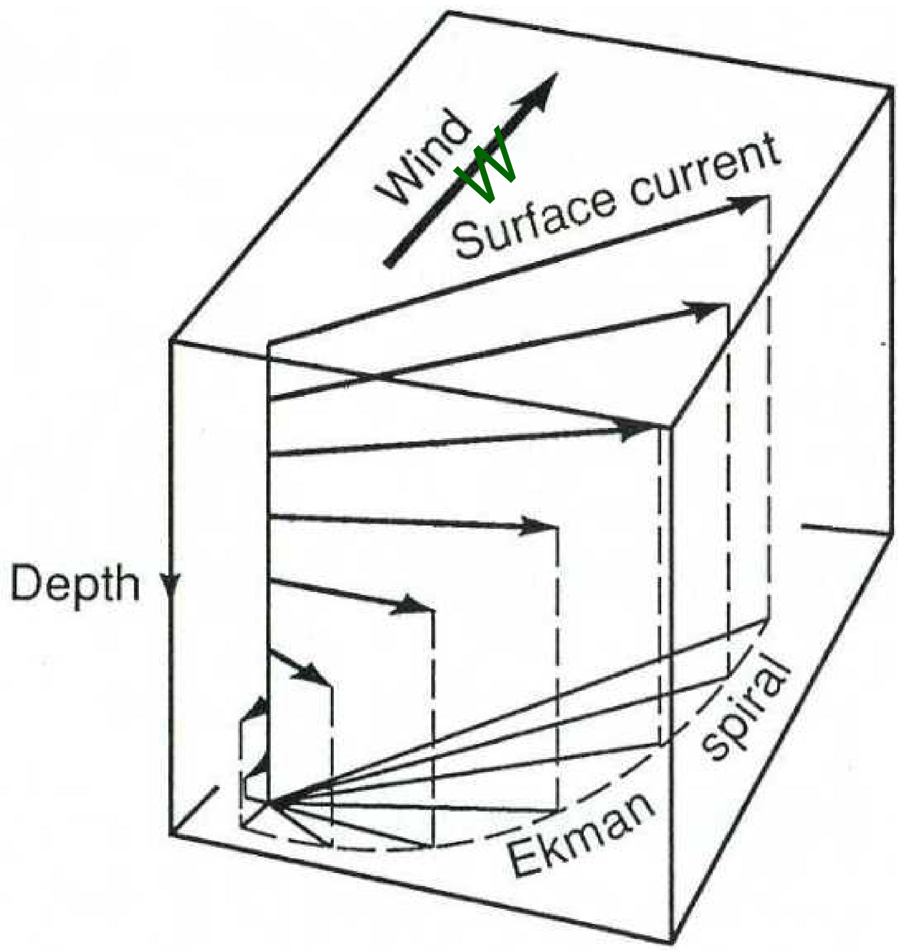
Wind Drift Current

$$\boldsymbol{u}_s = \boldsymbol{u}_i + \boldsymbol{u}_{wd}$$



Cushuman-Roisin (1994)

Drift Parameter



$$\boldsymbol{u}_{wd} = \boldsymbol{A}(\alpha,\theta)\boldsymbol{W}$$

$$A(\alpha,\theta) = \alpha\begin{pmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{pmatrix}$$

α: speed factor
θ: deflection angle
W: wind vector

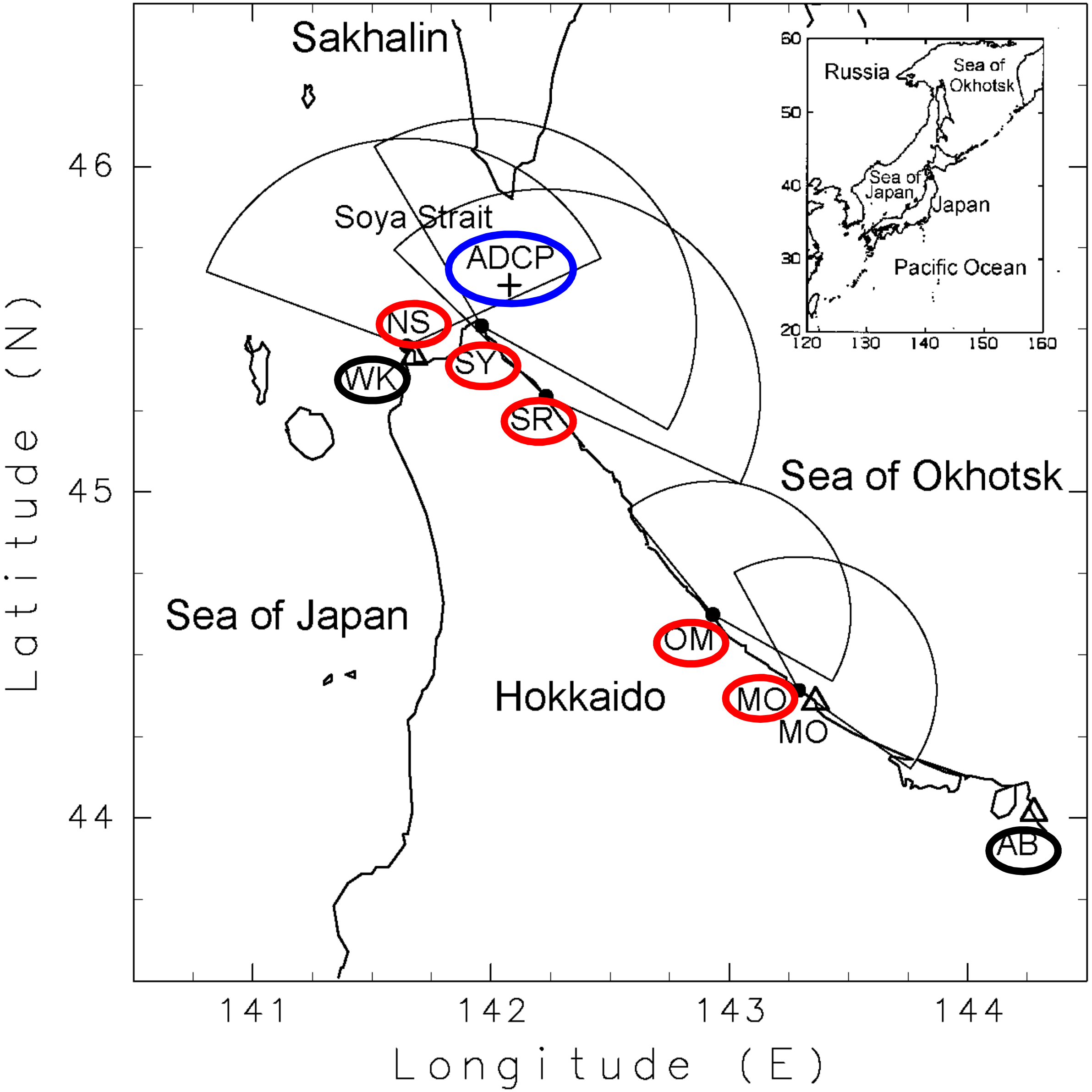
Cushuman-Roisin (1994)

How to calculate wind drift parameter

$$\min(\boldsymbol{u}_{err}) = (\boldsymbol{u}_s - \boldsymbol{u}_i) - \boldsymbol{A}(\alpha, \theta)\boldsymbol{W}$$

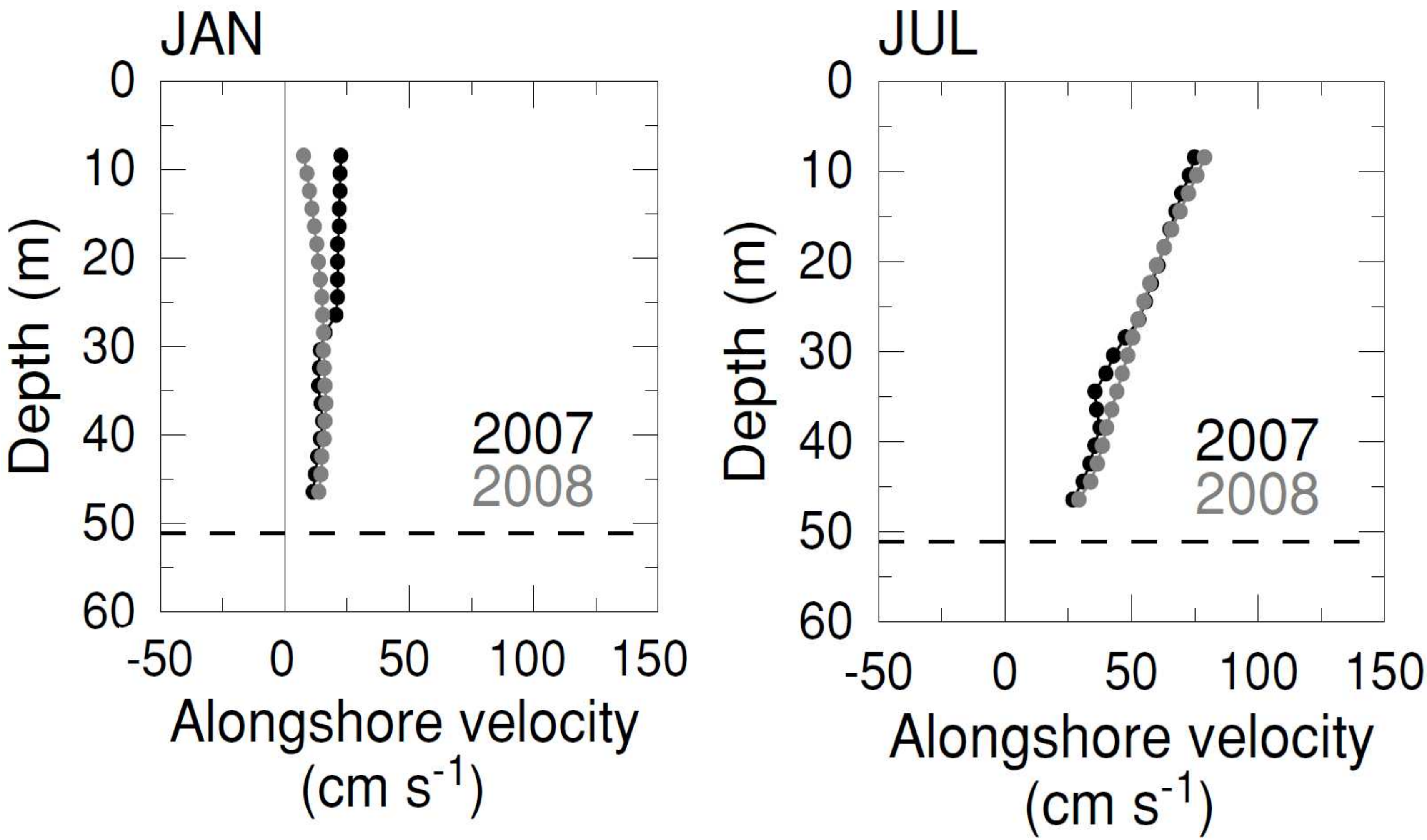
- Surface current (HF radar data)
- Interior current (ADCP data)
- Wind (JMA GPV/MSM)

Observation



- HF radars
- ADCP
  (Bottom mounted)
- Tide gauges
- Wind
  (JMA GPV/MSM)

Example of ADCP vertical profiles

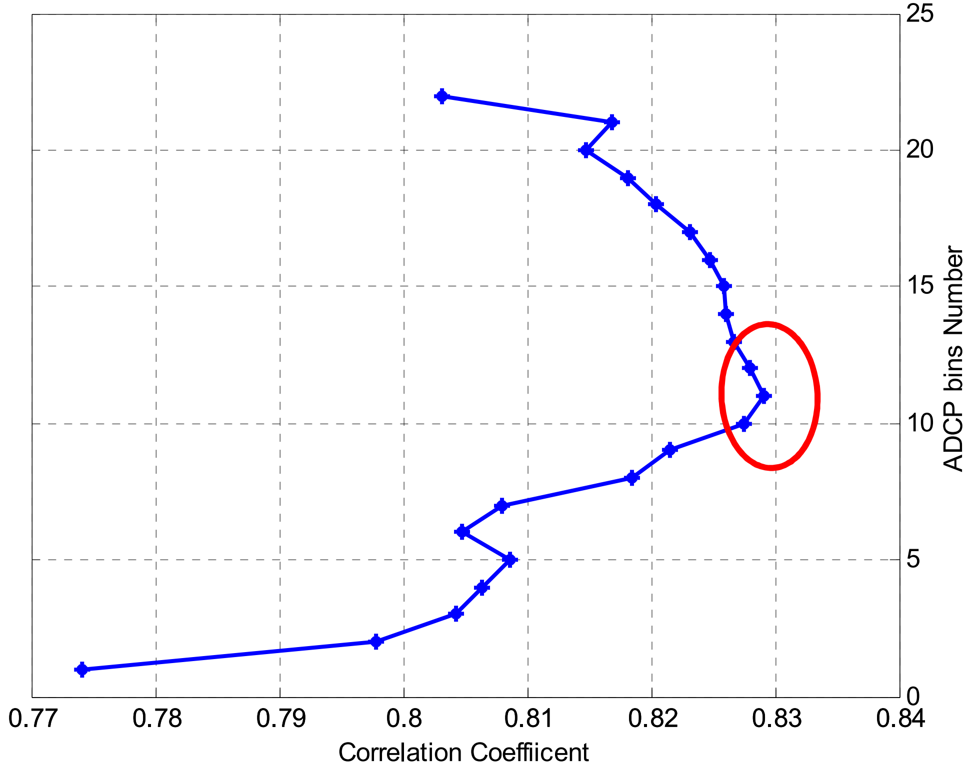


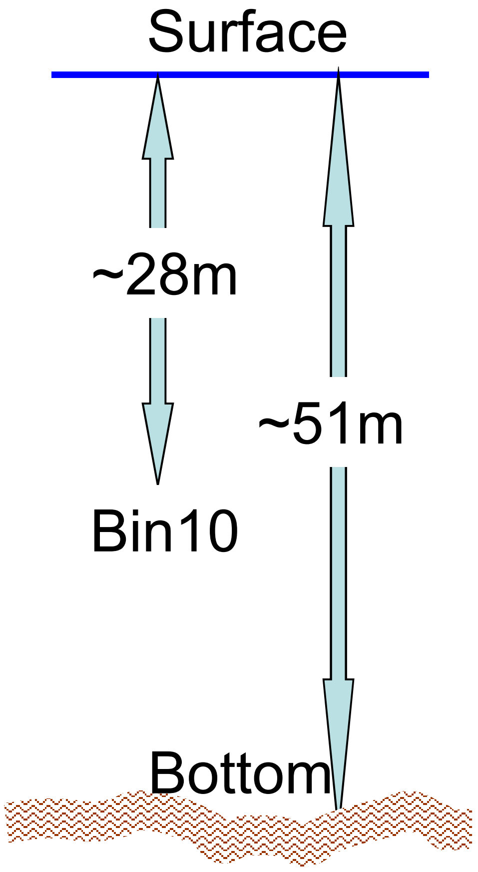
Monthly-mean of alongshore velocity observed by ADCP.

Fukamachi *et al*.(2010)

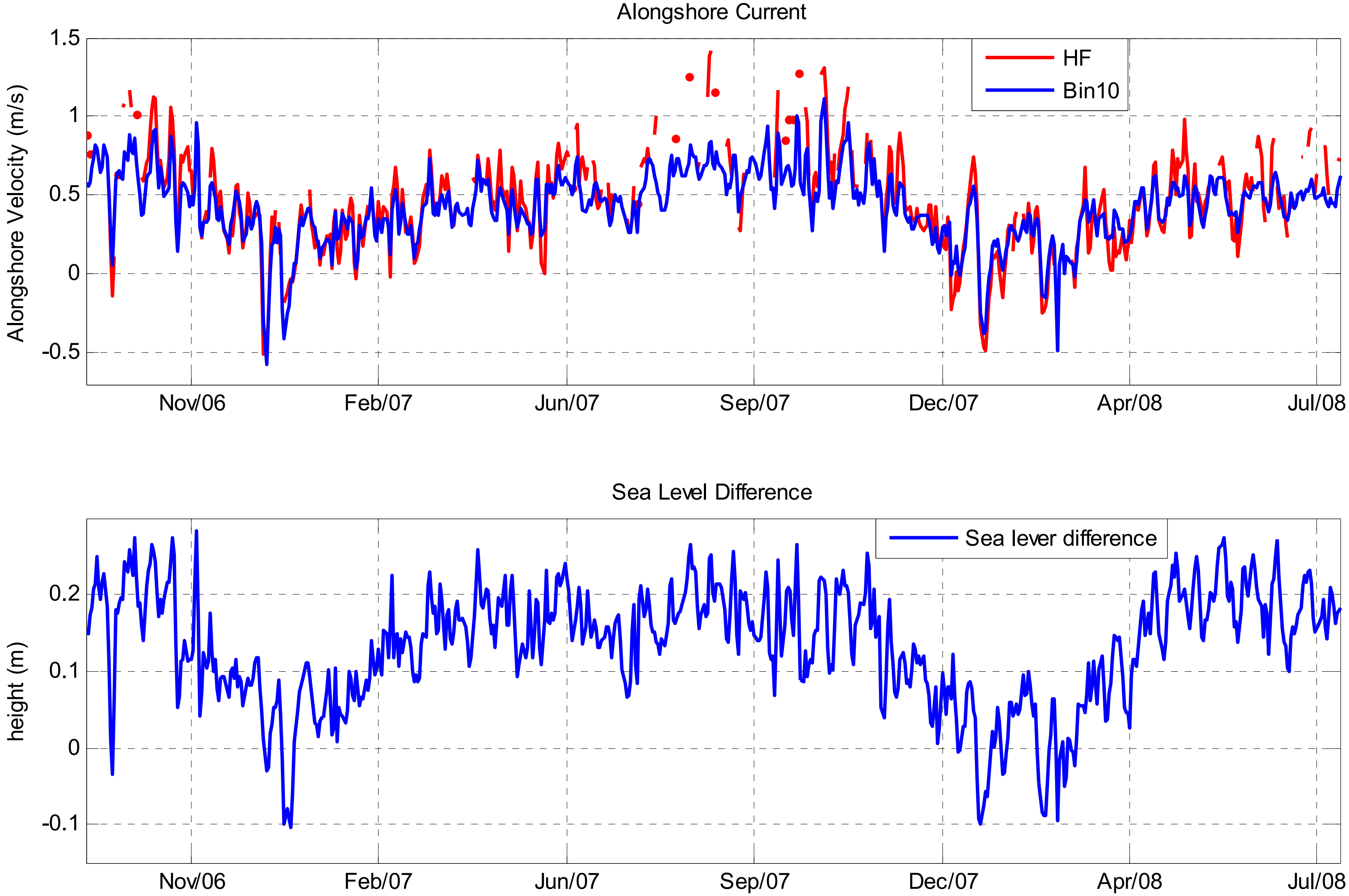
Interior Current

Correlation Coefficient between sea level difference and alongshore velocities of different ADCP bins.



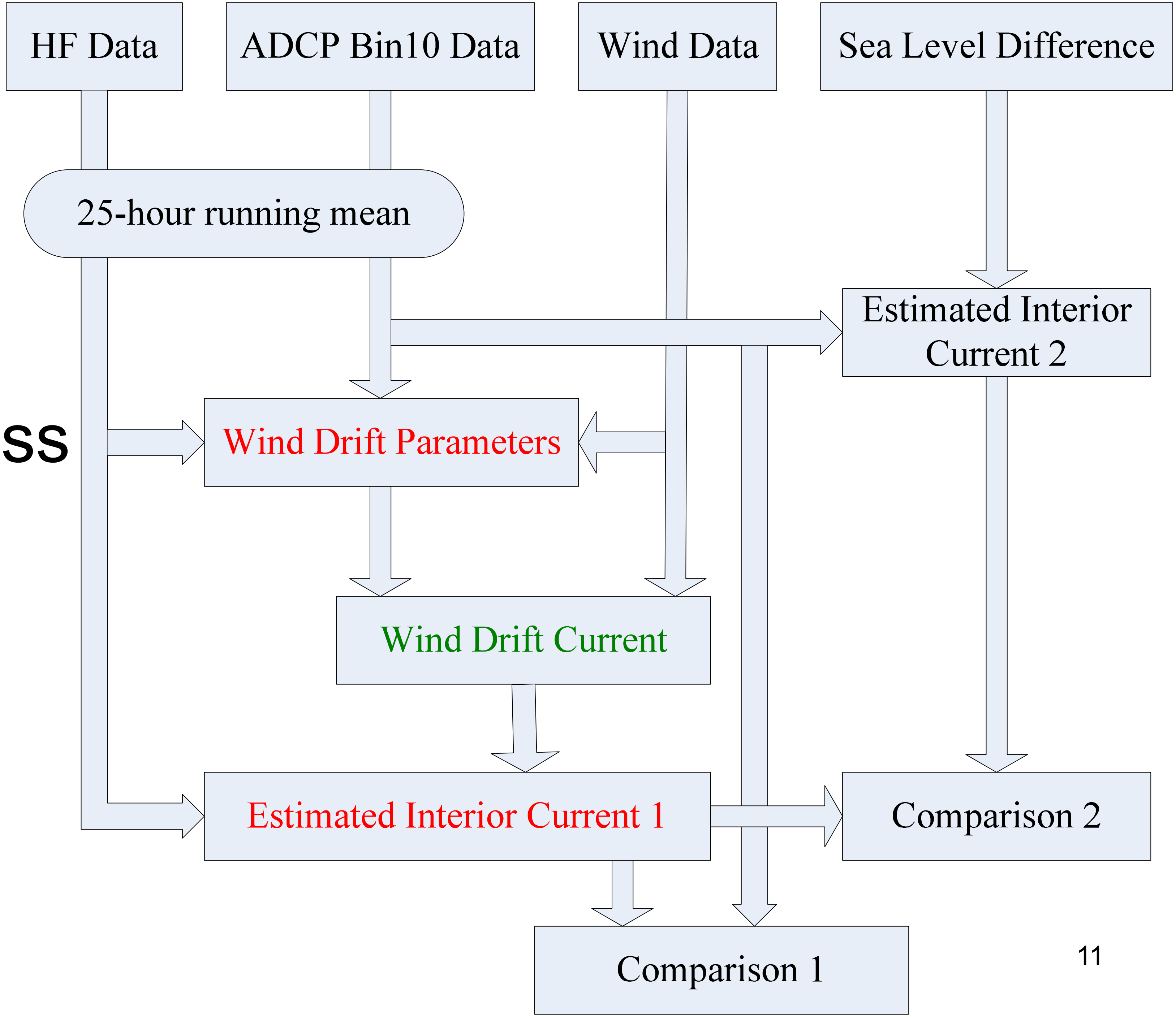


Bin10 VS. Sea Level Difference

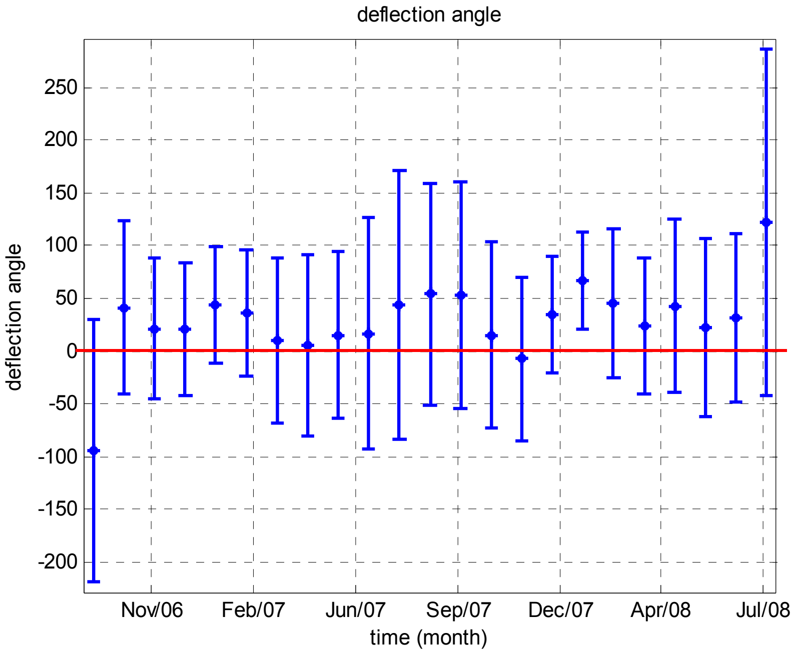


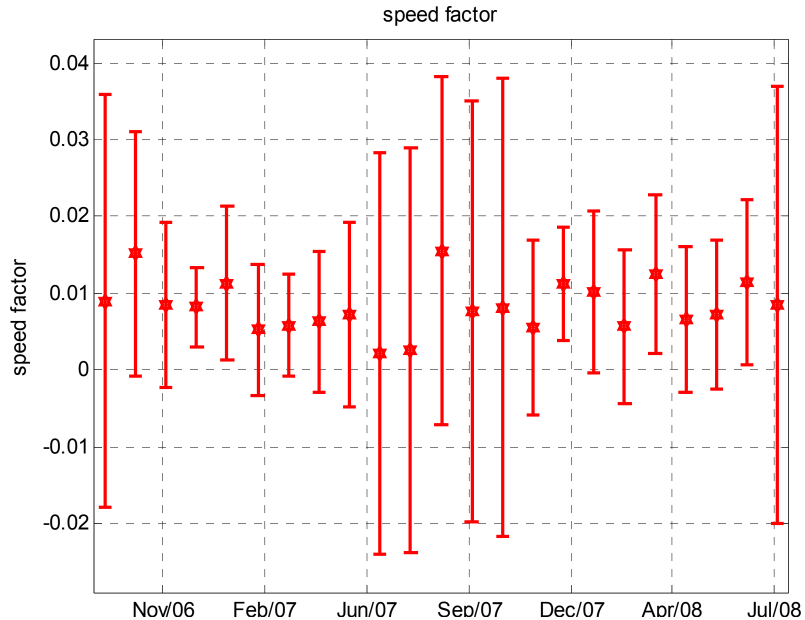
Alongshore velocities correspond well with sea level difference.

Process Steps

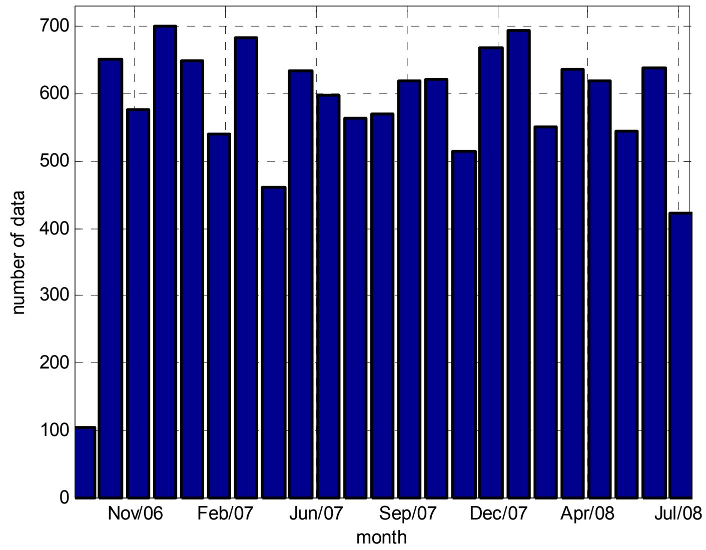


Monthly Drift Parameters





Root-Mean-Square error of monthly and daily drift parameters

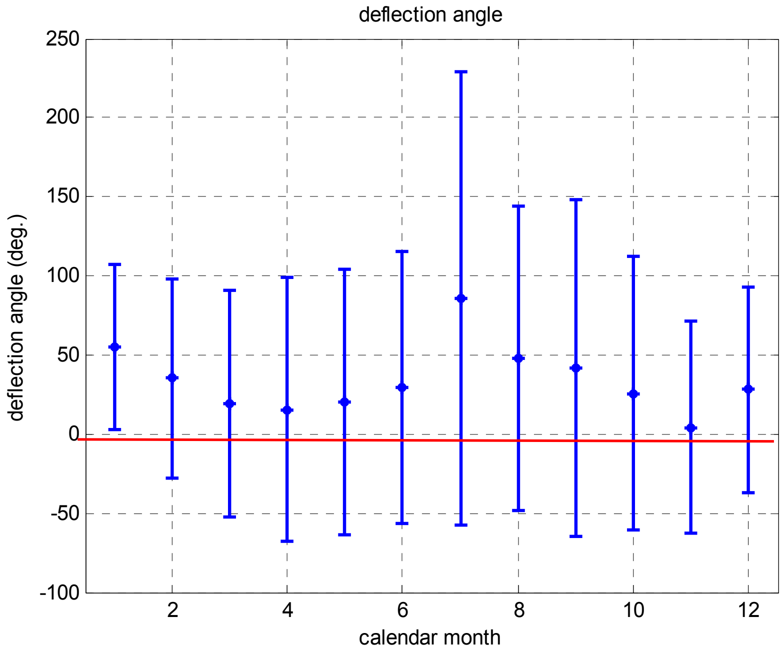


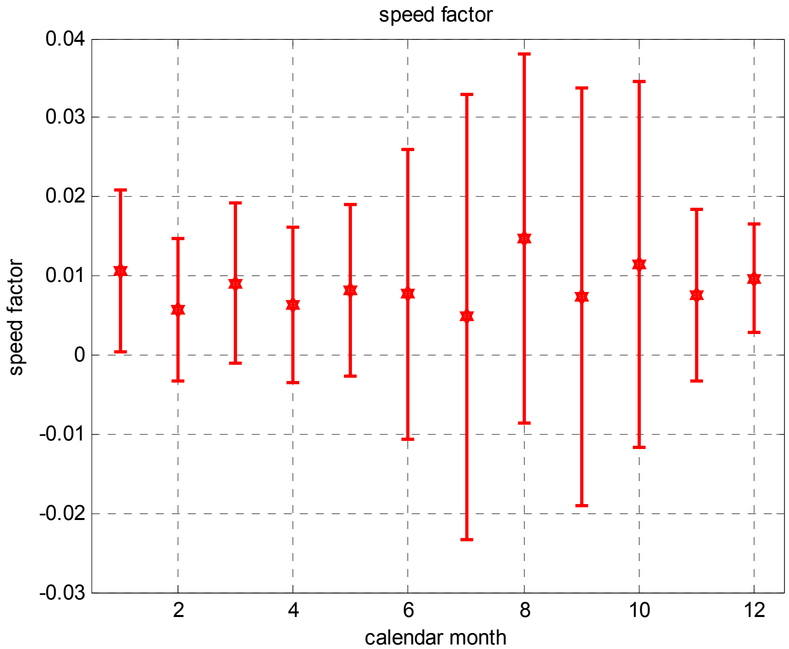
Average Drift Parameter

	value	RMSE
Deflection angle	34 deg.	83 deg.
Speed factor	0.0078	0.0156

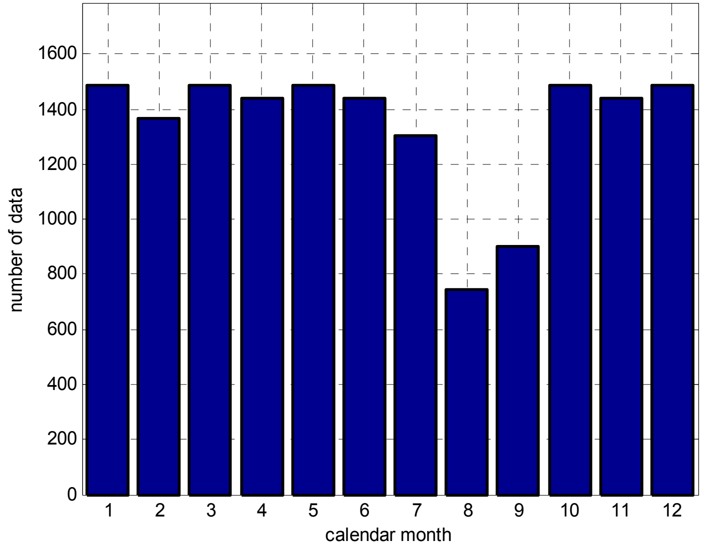
Root-Mean-Square error of average and daily drift parameters

Seasonal variation in drift parameters

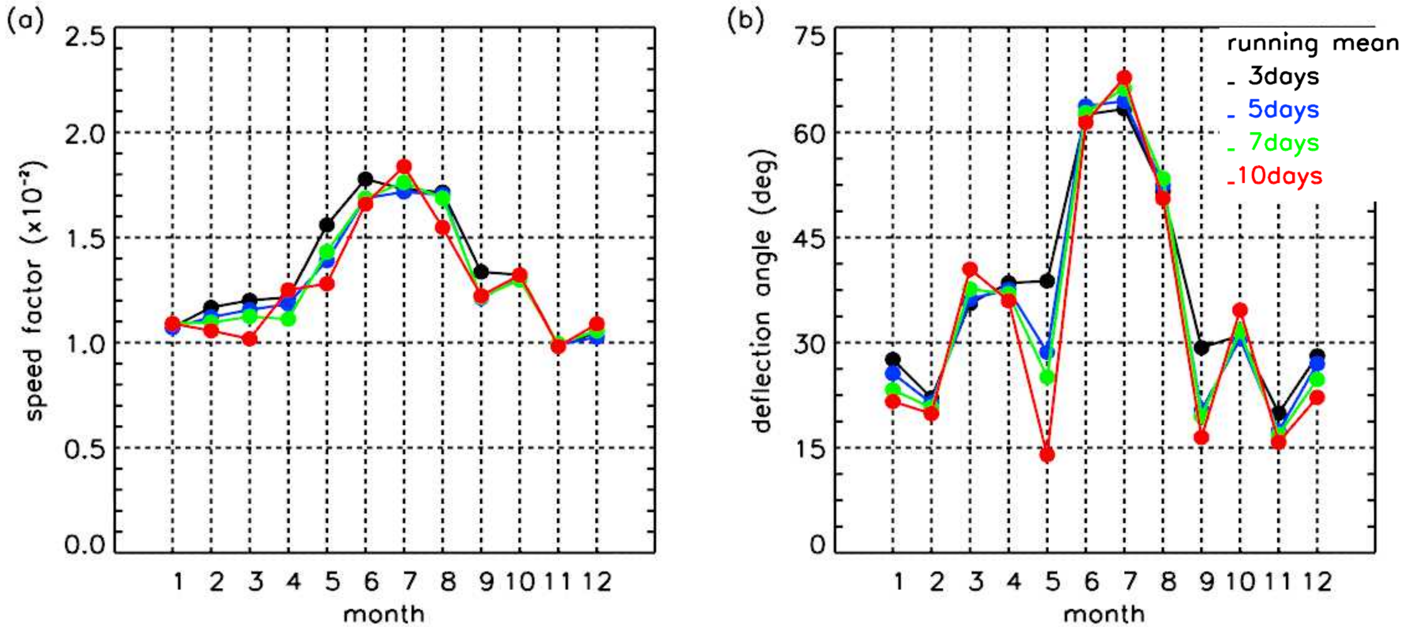




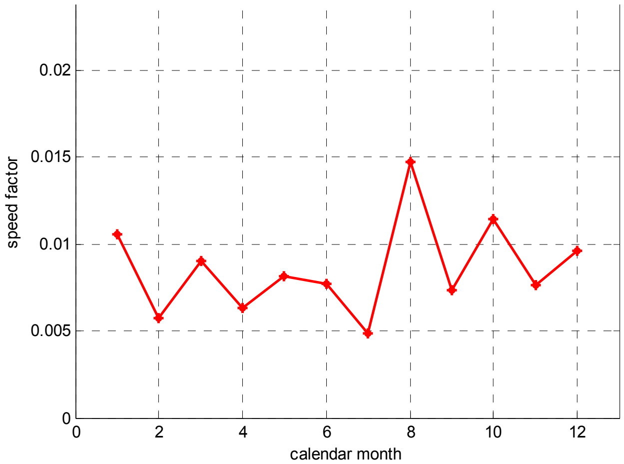
Root-Mean-Square error of calendar monthly and daily drift parameters

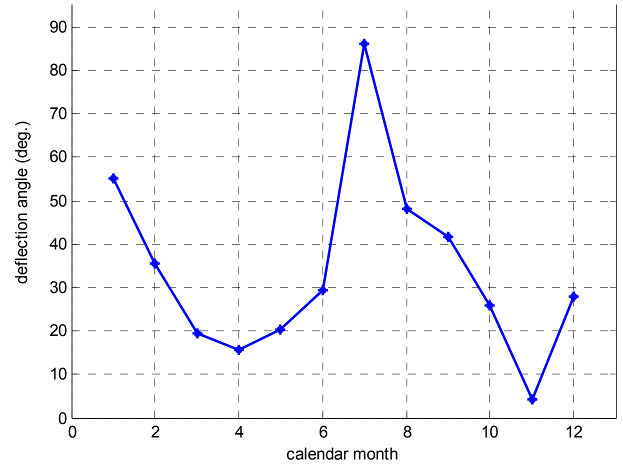


Seasonal variation comparison



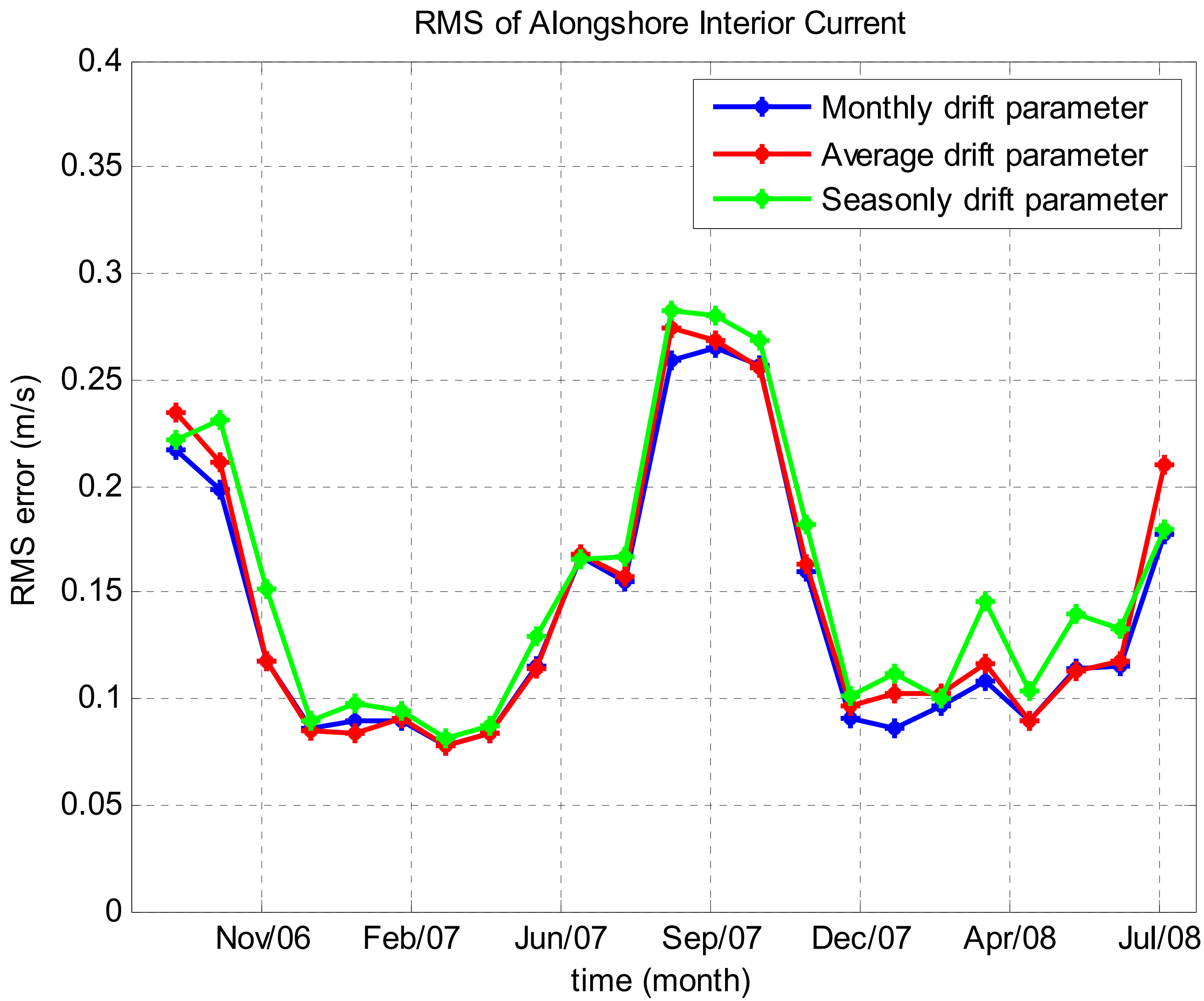
Yoshikawa and Masuda (2009)





Seasonal variation in drift parameters are not significant

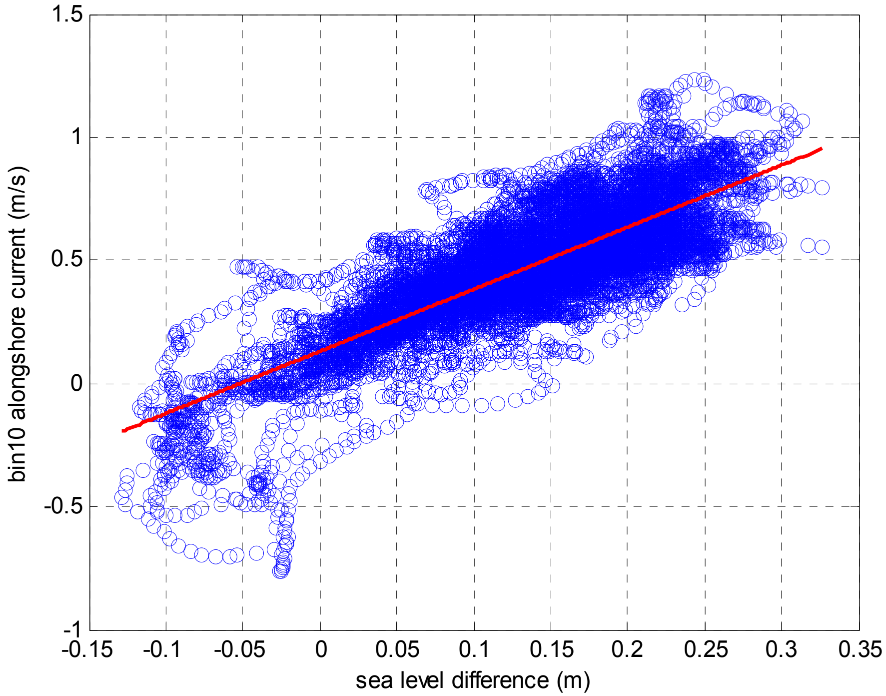
Comparison1 for alongshore component

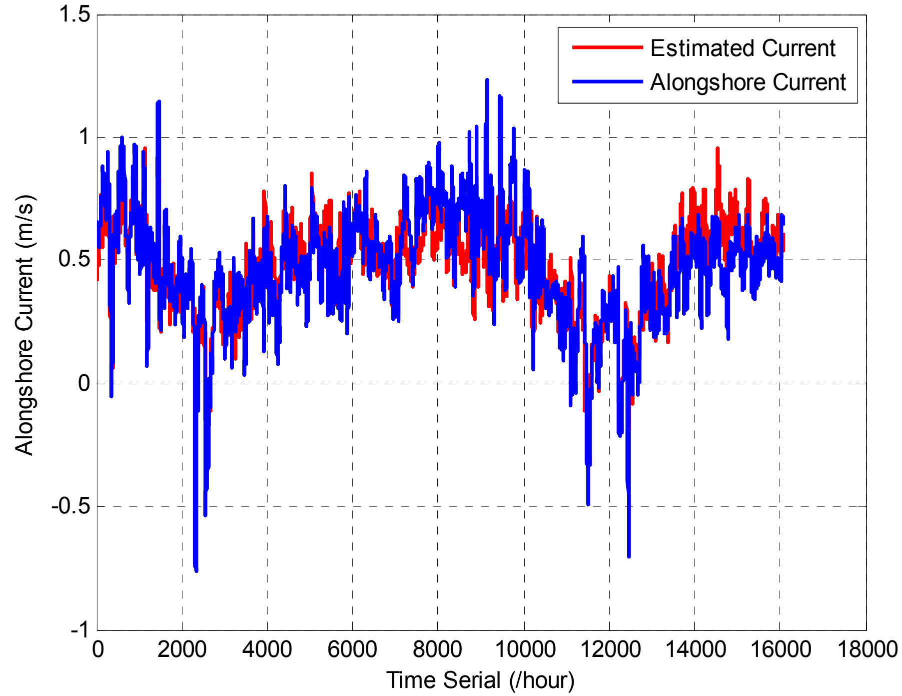


Correlation Coefficient
+: 90.35%
+: 90.23%
+: 90.34%

High Error: Aug. Sept. Oct. Low Error: Dec. Jan. Feb. Mar. Apr.

Relationship between sea level difference and Bin10

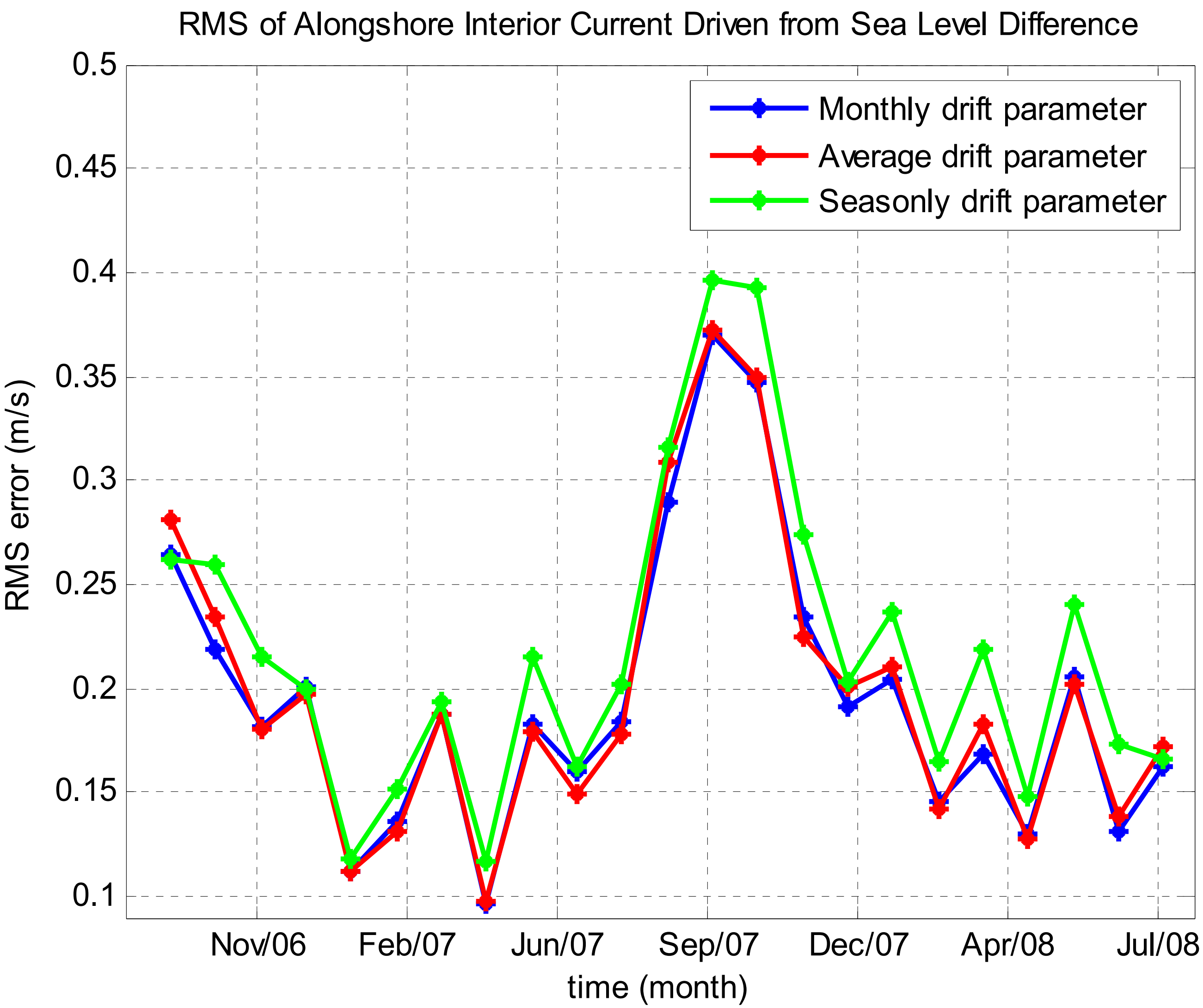




Correlation coefficient: 81.26%

$$u_{iSL} = a\Delta\eta + b \quad \Rightarrow \quad a = 2.52, \quad b = 0.13$$

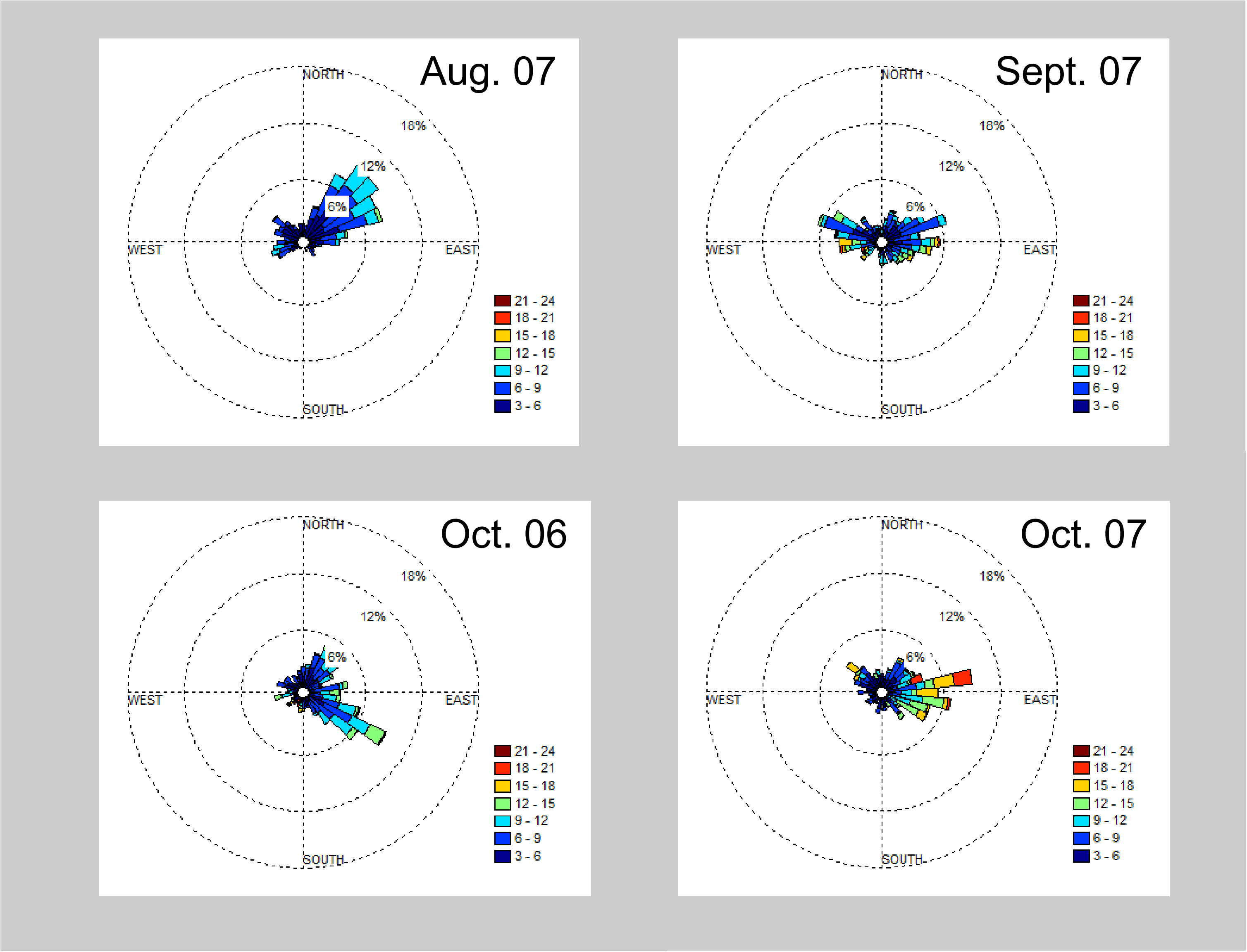
Comparison2 for alongshore component



Correlation Coefficient
+: 74.69%
+: 75.44%
+: 71.77%

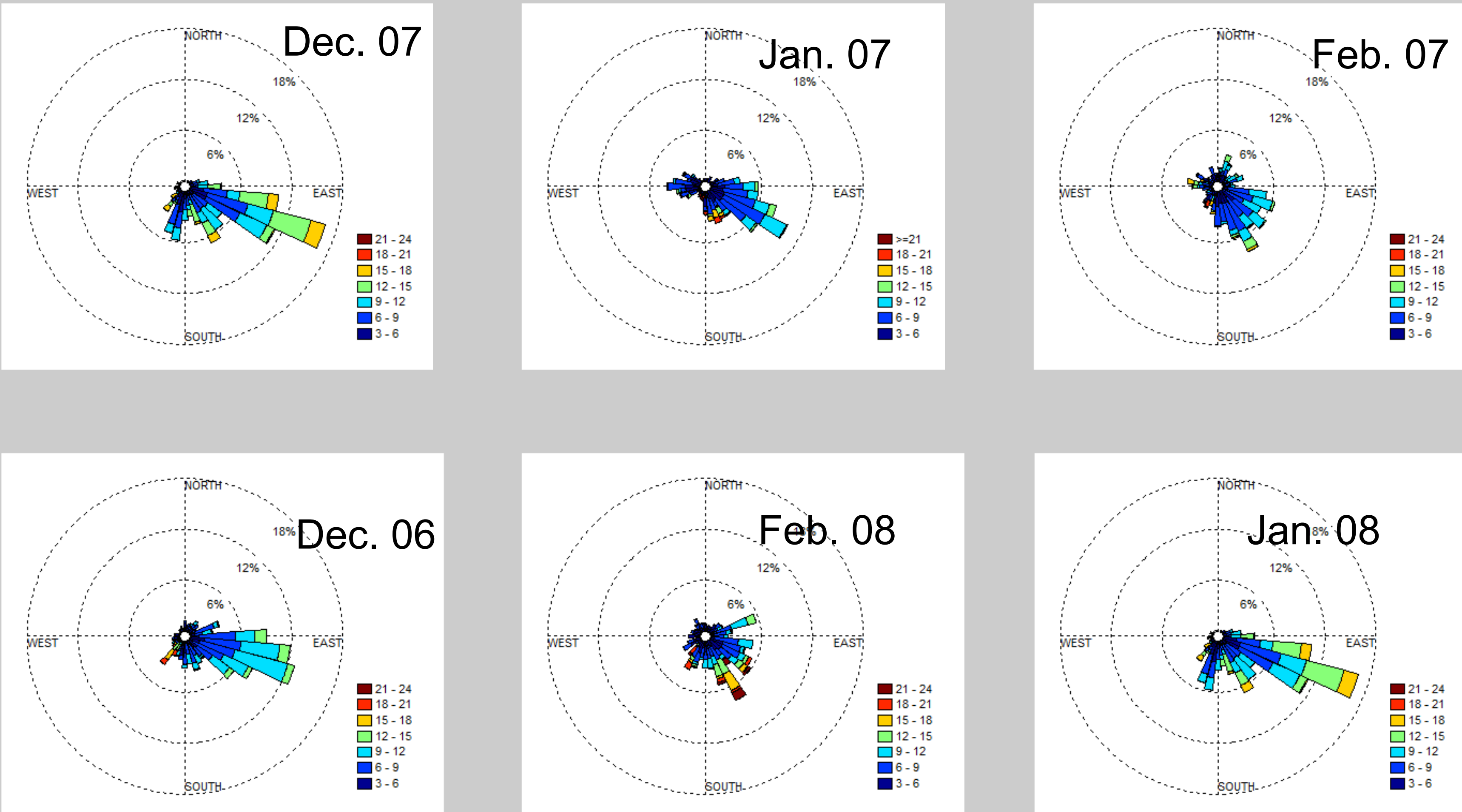
High Error: Aug. Sept. Oct.

Wind in Summer



The wind is weak, and its direction is unstable.

Wind in Winter



The wind is strong, and its direction is stable.

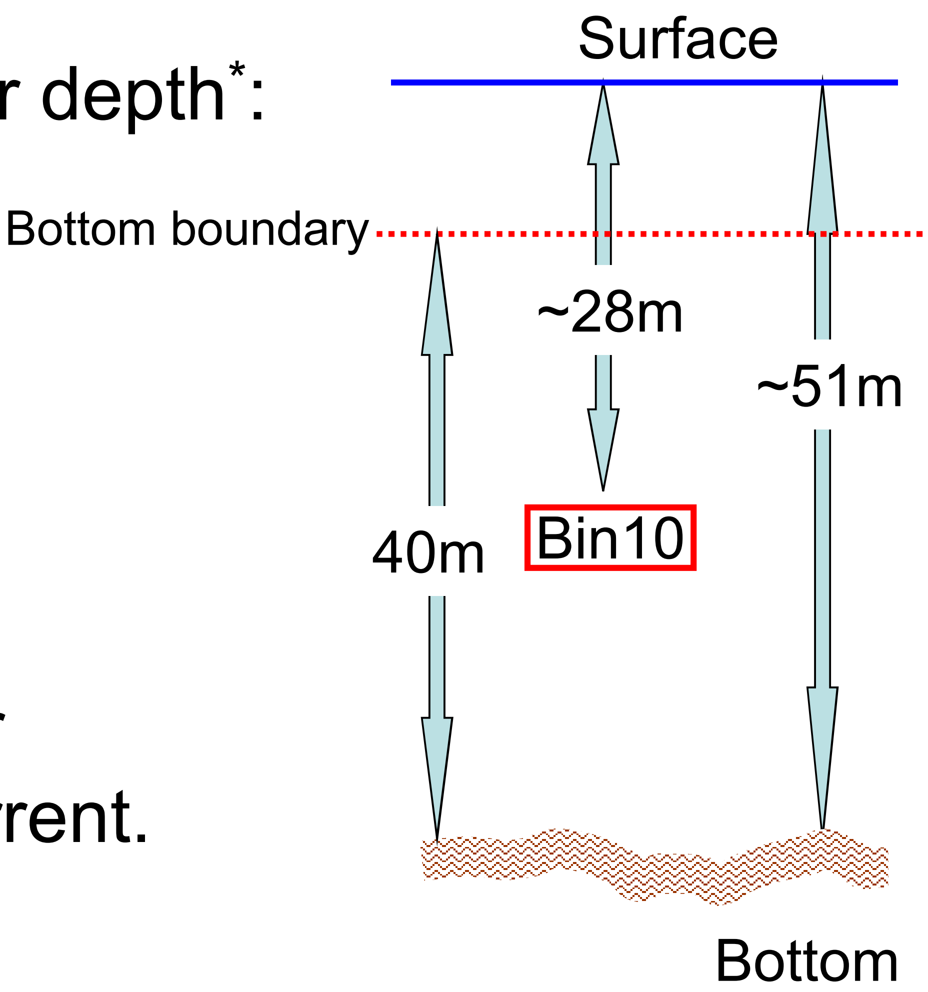
Affection of bottom on drift parameter

The bottom boundary layer depth*:

$$\delta_E \sim 0.4\frac{U_*}{f} \approx 40m$$

$$U_* \approx 10^{-2} ms^{-1}, f \approx 1\times 10^{-4} s^{-1}$$

The bottom boundary layer affects on the wind drift current.



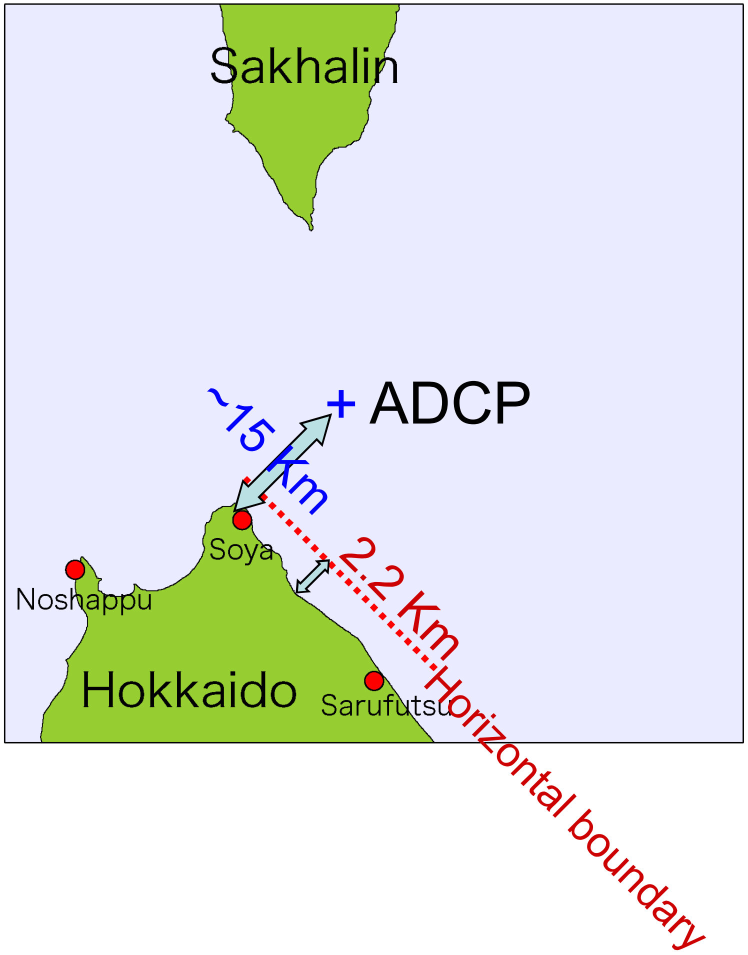
* Yoshikawa and Masuda (2009); Cushuman-Roisin (1994)

Affection of coastline on drift parameter

The horizontal boundary layer width*:

$$\delta_H = \left(\frac{2A_H}{f} \frac{D}{\delta_E} \right)^{1/2} \approx 2.2km$$

$$A_H = 200m^2 s^{-1}, D \approx 50m$$



The horizontal boundary layer effect on the wind drift current can be neglected.

* Yoshikawa and Masuda (2009); Pedlosky (1987)

conclusion

- Average drift parameter is a simple and effective way to estimate wind drift current.
- Wind drift current estimation is more accurate in winter and spring, but worse in summer and autumn.
- Seasonal variation in drift parameters are not significant.
- The bottom boundary layer affects wind drift current.

Main reference

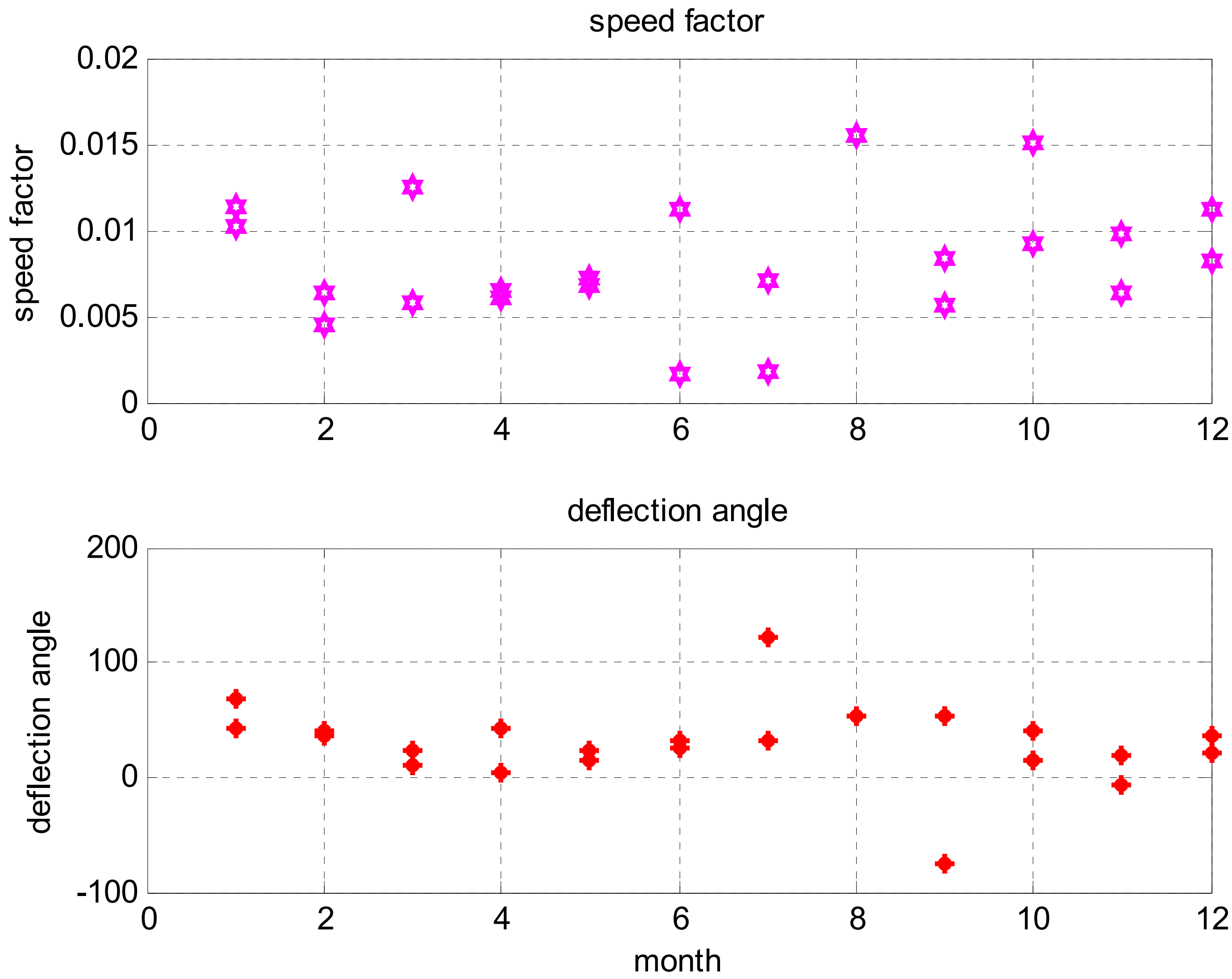
- Yoshikawa, Y. and A. Masuda (2009): Seasonal variations in the speed factor and deflection angle of the wind-driven surface flow in the Tsushima Strait. J. Geophys. Res. Oceans, 114, C12022, doi:10.1029/2009JC005632.
- Cushuman-Roisin, B. (1994), Introduction to Geophysical Fluid Dynamics, 320 pp., Prentice-Hall, Englewood Cliffs, N. J.
- Fukamachi, Y., K. I. Ohshima, N. Ebuchi, T. Bando, K. Ono, and M. Sano (2010): Volume Transport in the Soya Strait during 2006-2008, *Journal of Oceanography, 66*, 685-696.
- Pedlosky, J. (1987), Geophysical Fluid Dynamics, 2nd ed., 710 pp., Springer, New York.

Thank you for your attention!!!

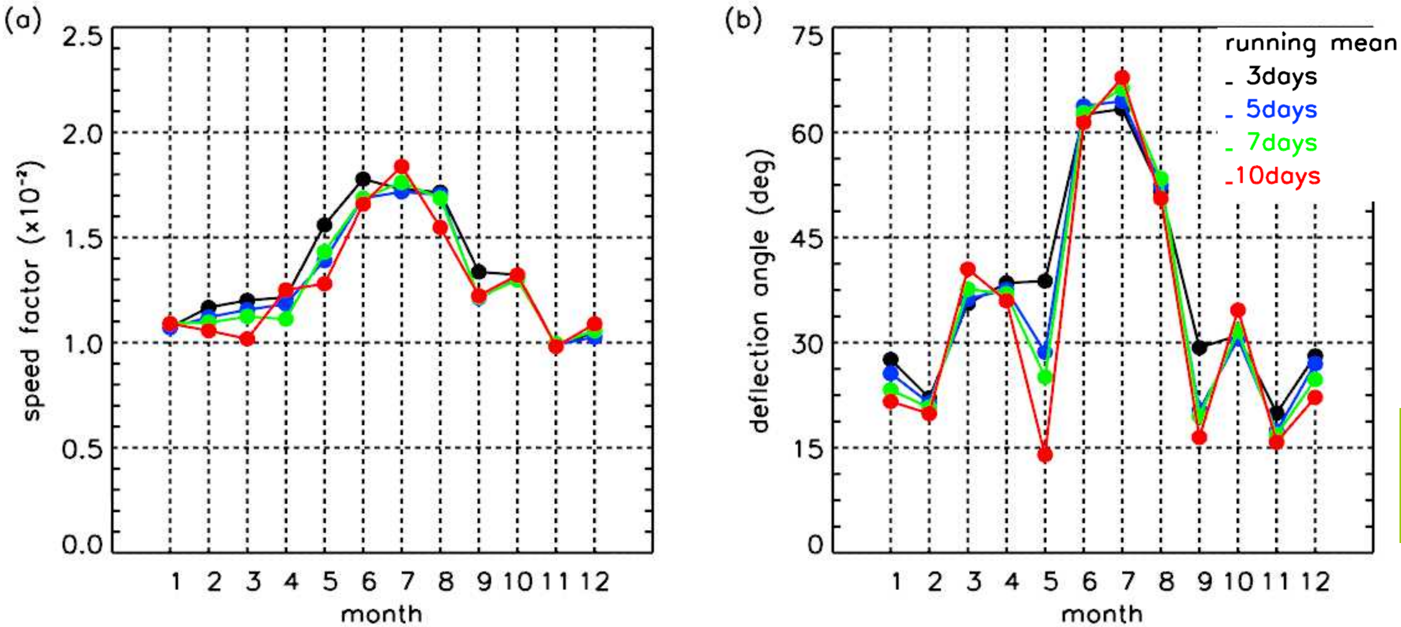
Back up

Back up

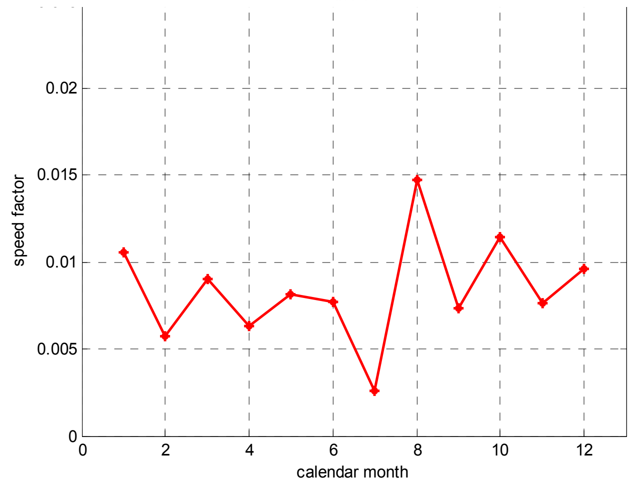
Monthly drift parameter in seasonal variation

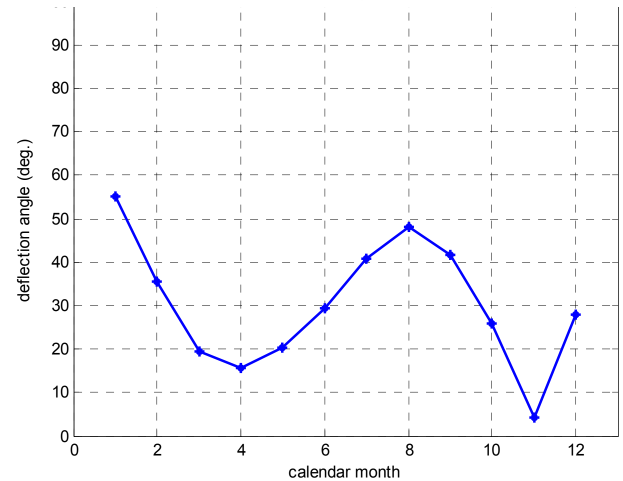


Seasonal variation comparison



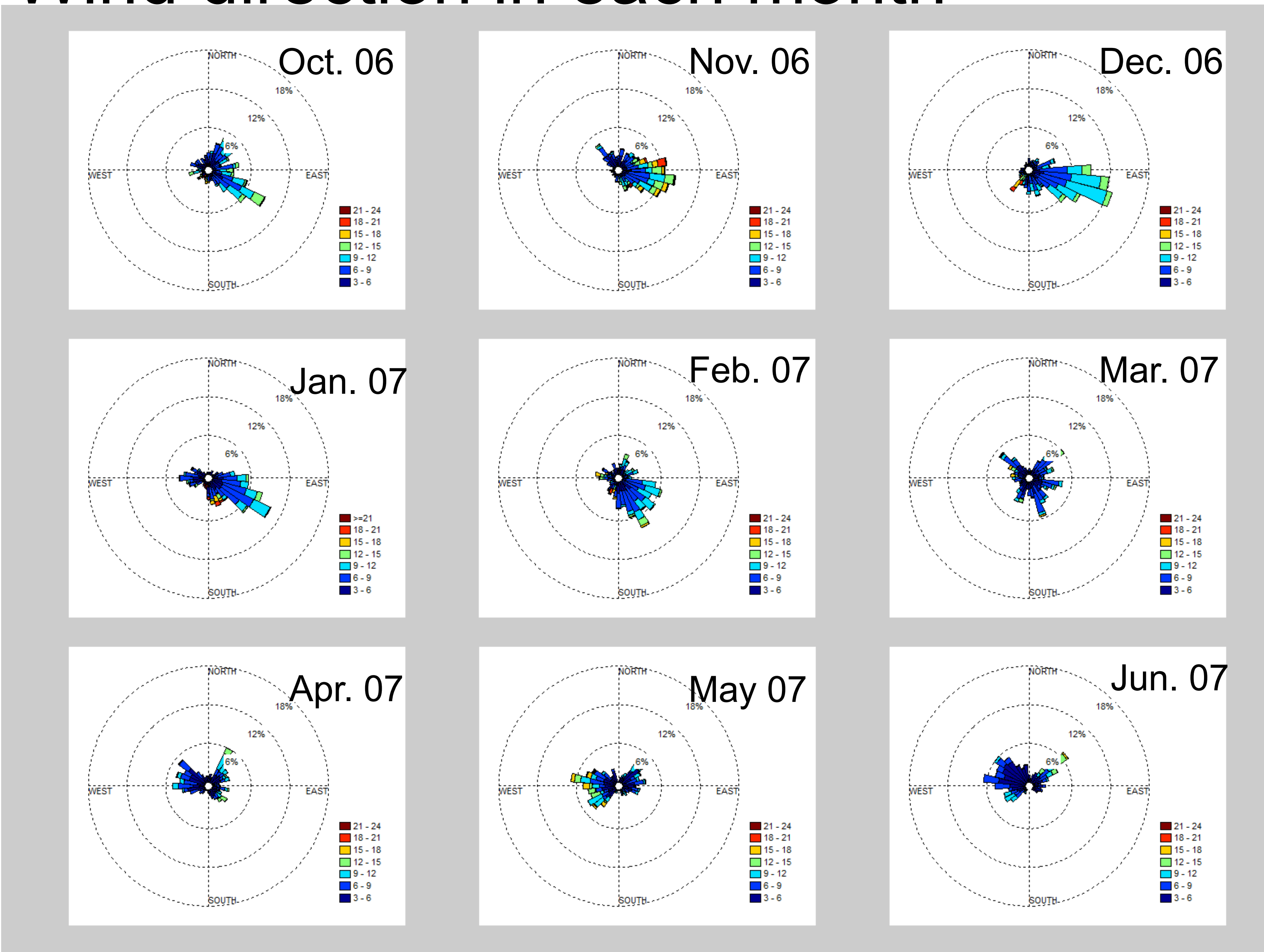
Yoshikawa and Masuda (2009)



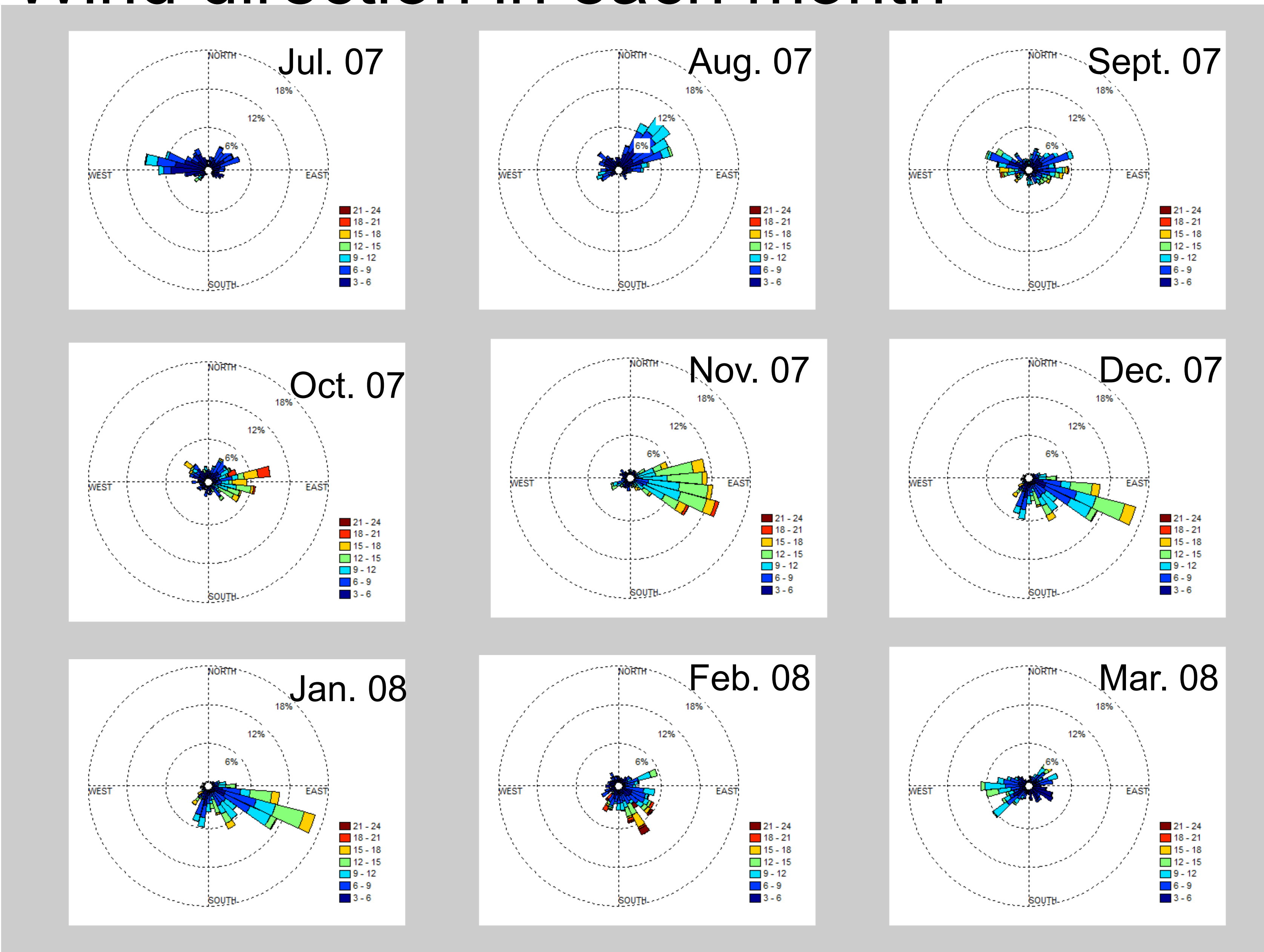


Seasonal variation in deflection angles are obvious.

Wind direction in each month



Wind direction in each month



Wind direction in each month