Simulation of wave-induced current considering wave-tide interaction in Haeundae

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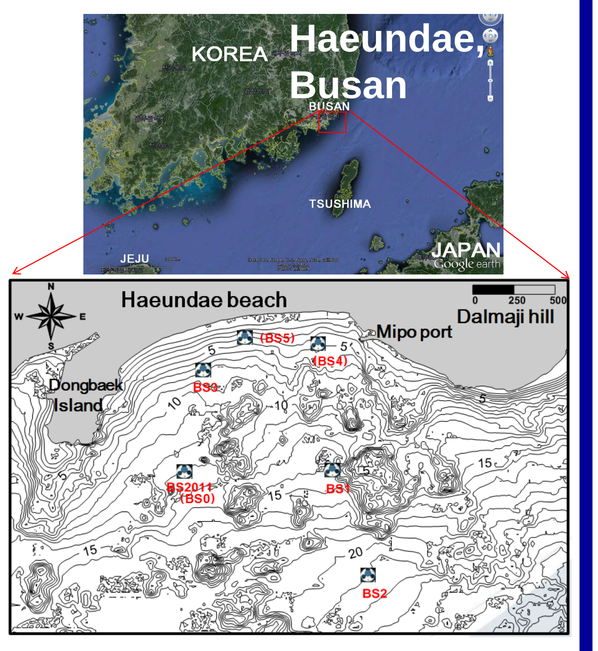
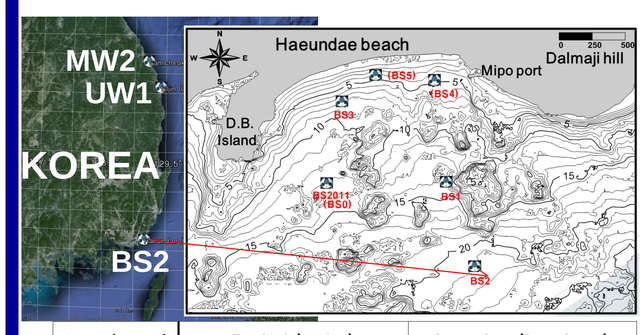
Abstract

The Haeundae, located at the southeastern end of the Korean Peninsula, is a famous beach, which has an approximately 1.6 km long and 70 m wide coastline. The beach has been repeatedly eroded by the swell waves caused by typhoons in summer and waves originating in the East Sea in winter. The Korean government has been recently conducting beach restoration projects including beach nourishment (620,000 m^3) and construction of two submerged breakwaters near both ends of the beach along with a five-year R&D project regarding the development of coastal erosion control technology. As a part of the project, we have been measuring waves and currents at a water depth of 22 m, 1.8 km away from the beach using an acoustic wave and current meter (AWAC) continuously for more than three years; we have also measured waves and currents near the surf-zone in summer and winter. We have simulated wave-induced currents according to the seasons considering wave–tide interaction using a wave-current coupled model and comparing the results with analyzed longshore currents measured by the AWACs. In this study, the variability of wave-induced currents was analyzed to understand the mechanism of coastal processes and sediment transport calibrating and validating the simulated results with observed waves and currents. We found that the cross-shore current near the middle of the beach during in summer arises mainly owing to the eddies generated by strong waves coming from SSW and S. In fall and winter, the longshore current, from the East, Mipo-port to the West, Dong-Back Island is developed owing to swell waves coming ESE and E.

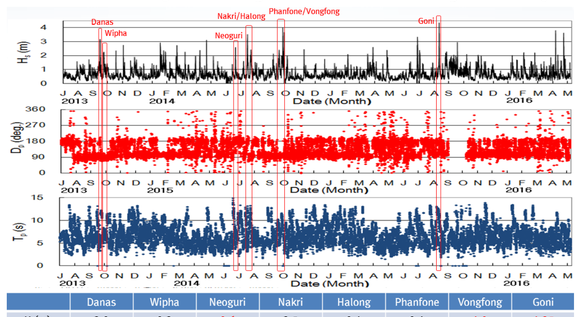


AWAC observation

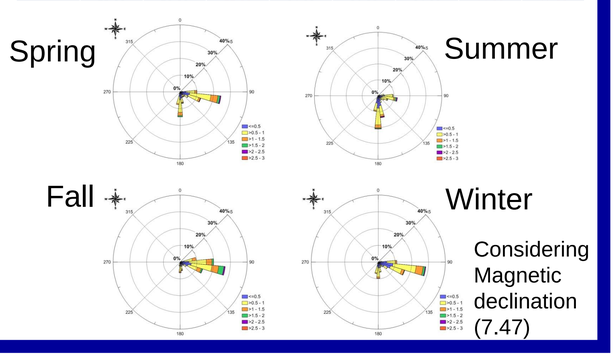


Sites (depth)	Period (order)	Location (Lat.,Lon.)
BS1(15m)	(1_{st}) 2013.07.25~2013.10.31	35°09.013’ , 129°10.139’
	(2_{nd}) 2013.10.31~2014.03.11	35°09.028’ , 129°10.153’
BS2(22m)	(1_{st}) 2013.07.25~2013.10.31	35°08.663’ , 129°10.280’
	(2_{nd}) 2013.10.31~2014.03.11	35°08.645’ , 129°10.308’
	(3_{rd}) 2014.03.11~2014.06.19	35°08.676’ , 129°10.383’
	(4_{th}) 2014.07.05~2014.10.13	35°08.633’ , 129°10.350’
	(5_{th}) 2014.10.14~2015.02.06	35°08.698’ , 129°10.383’
	(6_{th}) 2015.02.06~2015.06.10	35°08.716’ , 129°10.367’
	(7_{th}) 2015.06.10~2015.10.20	35°08.733’ , 129°10.317’
	(8_{th}) 2015.10.20~2016.05.17	35°08.716’ , 129°10.317’
BS3 (8m)	(1_{st}) 2013.08.07~2013.10.31	35°09.357’ , 129°09.609’
BS4 (6m)	(1_{st}) 2014.02.13~2014.3.28	35°09.447’ , 129°10.088’
BS5 (4m)	(1_{st}) 2014.08.24~2014.10.17	35°09.475’ , 129°09.798’
BS0(14m)	(1_{st}) 2011.07.06~2011.8.18	35°09.017’ , 129°09.533’

BS2 (25 July 2013~17 May 2016)



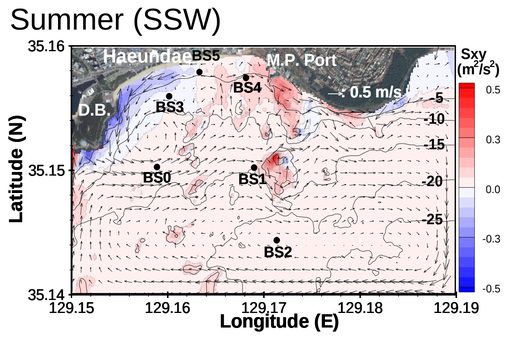
	Danas	Wipha	Neoguri	Nakri	Halong	Phanfone	Vongfong	Goni
H_s(m)	3.2	2.3	2.6	3.5	2.4	2.4	4.0	4.35
T_p(sec.)	9.2	11.7	11.8	7.5	9.0	9.4	10.5	11.49
D_p(deg.)	120.3	101.6	180.8	155.3	113.2	109.3	117.4	121.45
Date(peak)	13/10/08 23:00	13/10/16 20:00	14/07/09 22:00	14/08/03 04:00	14/08/10 05:00	14/10/06 04:00	14/10/13 14:00	15/08/25 17:00



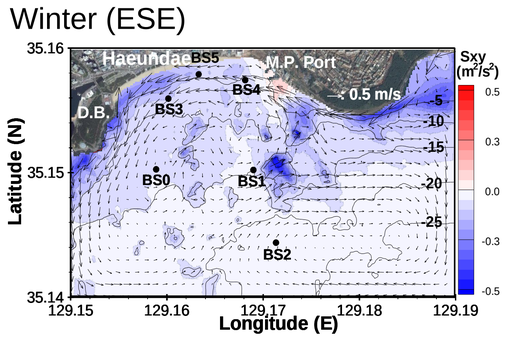
Considering Magnetic declination (7.47)

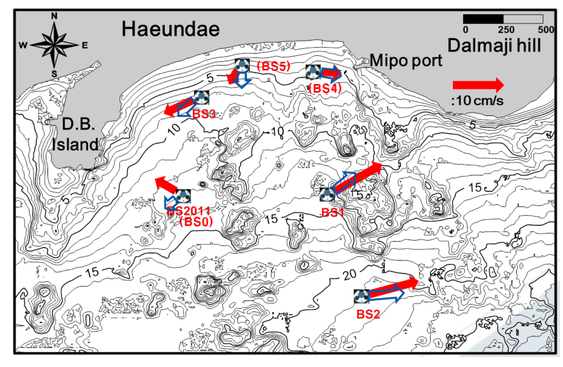
Wave-induced current vs. Residual current

Summer (SSW)



Winter (ESE)

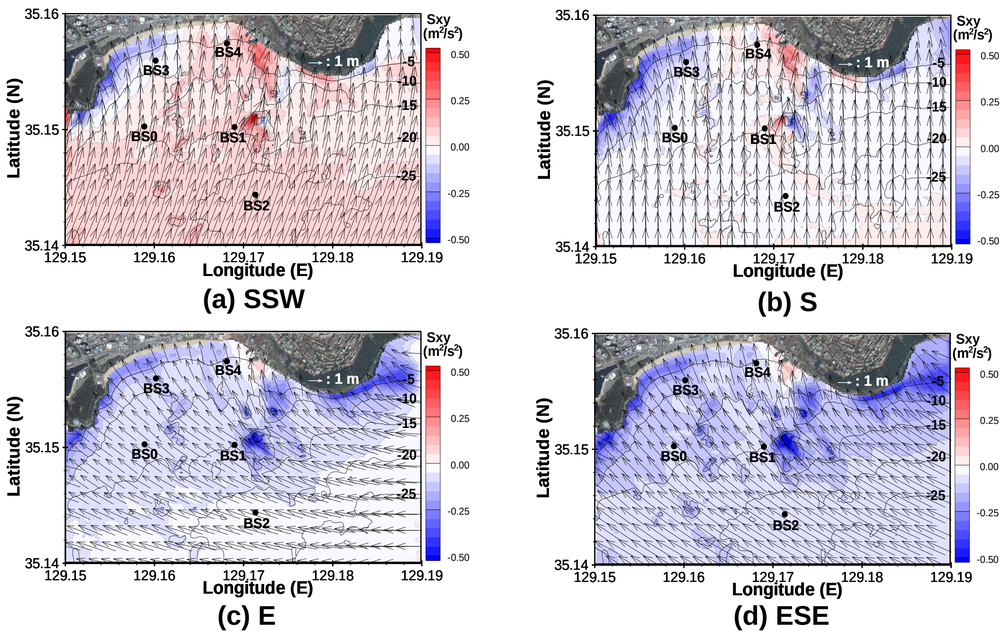




Averaged residual currents at surface (filled arrow) and bottom (empty arrow) in Haeundae coastal waters estimated by bottom-mounted AWAC flow data observed during from 25 July 2013 to 14 September 2015.

Bottom wave–induced current and horizontal radiation stress(S_{xy}) simulated by ROMS–SWAN under wave condition of 2.5m(H_s), 12s(T_p) for different directions (SSW, ESE).

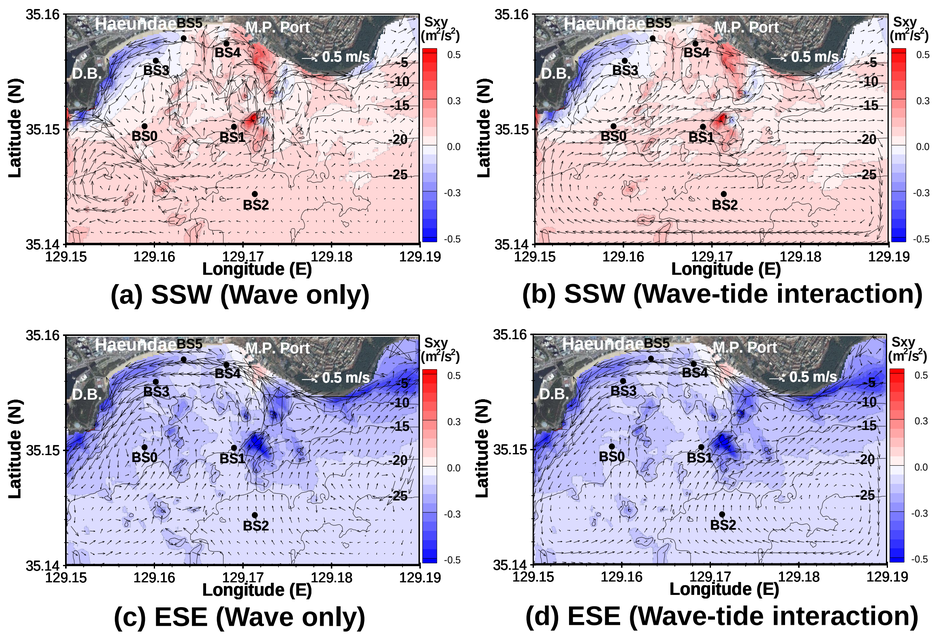
Radiation Stress simulated by ROMS-SWAN



(a) SSW (b) S (c) E (d) ESE

Significant wave height(H_s) and Surface horizontal radiation stress(S_{xy}) simulated by ROMS–SWAN under wave condition of 2.5m(H_s), 12s(T_p) for different directions (SSW, S, E, ESE).

Comparison of wave-induced current W/WO interaction



(a) SSW (Wave only) (b) SSW (Wave-tide interaction)

(c) ESE (Wave only) (d) ESE (Wave-tide interaction)

Surface wave–induced current and horizontal radiation stress(S_{xy}) simulated by ROMS–SWAN under wave condition of 2.5m (H_s), 12s (T_p) for different direction (SSW, ESE).

Conclusions

- Variability of wave and residual current in Haeundae has been estimated by bottom-mounted long-term observed AWAC data.
- High-resolution wave and current coupled model (ROMS-SWAN) used for wave-induced current considering wave-current interaction.
- Variation of wave height and direction near the beach was caused by shoaling, refraction and breaking near surf-zone and shoals according to the wave direction coming from SSW, S in summer and ESE, E in winter.
- Longshore residual currents were generated mainly due to wave-induced current because of the wave breaking in shallow water with bottom bathymetry (submerged shoals) and geometric coastline (headlands).
- Wave-induced current generates longshore current from East to West heading toward Dong-Back Island in all seasons and also generates eddy current heading East toward Mipo Port in summer and even in winter showing good agreement with observed residual current.

Reference

Lim, H.S., Chun, I.S., Shim J.S. and Kim, C.S. (2016). “Wave-induced current simulated by wave-current coupled model in Haeundae.” JCR, SI.75, pp.1392-1396.