Formation of the Vortex of Sea/Land Breeze in a Coastal Area
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1. Introduction
More than half of the worldwide population lives in cities compared to 50 years ago and approximately half of the population now live in coastal area within the 50km range (Hodges et al., 1993; Von Bodungen et al., 2001). It is essential to understand the interaction between emissions and the coastal atmosphere to maintain the coastal environment for increased population (Pryor et al., 2008; Lee et al., 2000). Similarly, Incheon city, located in west coast of Korean Peninsula as in Fig. 1, has rapidly been growing as a residential area. In addition, major energy sources power plants, air port, ports, etc. have been in operation near coastal line and nearby islands that subsequently affect the local air quality (Jung et al., 2009). This change in surface coverage and urbanization blocks the air flow in highly constructed area and accelerates it in the space between buildings (Yamada, 2004).

![Study site (a) South Korean peninsula, and (b) magnifying view of study domain.](image)

Incheon city frequently experiences a circulation of wind from land to sea, i.e. land breeze, and vice-versa, i.e. sea breeze, where sea breeze was observed about 200 times in year 2000 (Jeong et al., 2008). The vortex of sea/land (S/L) breeze depends on the geography, land use pattern, solar radiation, albedo, temperature/pressure gradient, inversion height etc. and the resulting air flow affects the transport of air pollutants from origin. Lee et al. (2004) reported that inversion layer reached up to 200 m~300 m during the worst atmospheric condition but in general the average inversion layer in the area is approximately 1,000 m from the ground surface.

2. Modeling method
This study especially focuses on the formation of vortex and its pattern during different stages of S/L breeze in a coastal area using numerical simulation technique. Numerical simulation was
performed using a commercial software A2C flow / A2C (t&d) by setting up the modelling domain of size (125.22E, 36.32N to 127.95E, 38.38N) which covers Incheon, Seoul as in Fig. 1. The initial and boundary conditions were set up based on the monitored meteorological data and related literature reviews. As we considered pure S/L breeze, the initial wind speed was set up to 0 m/s. Modeling period was also set up on mid of July for a week when frequent S/L breeze was observed representing a typical summer period (Jeong et al., 2007). Finally, the depth as well as the horizontal length of vortex were analysed based on modeling result.

3. Air dispersion characteristics

S/L breeze has been an important issue for coastal environment because of its significant role for transport and diffusion of air pollutants generated in a coastal area. In this study, the meso-scale modeling tool A2C flow was successfully applied to analyze the pure S/L breeze where strong land breeze was obtained at about 6AM: just before sunrise and it was neutralized between 9AM~10AM then the sea breeze started. The sea breeze achieved its optimum strength at about 3PM and again retarded continuously. Sea breeze loosened its energy while sun radiation intensity declined with time passed and again reached to transition period at about 8PM~10PM.

Fig. 2. Vertical crossection of vortex at (a) 6AM: maximum velocity of land breeze, (b) 10AM: transition period and (c) 3PM: maximum velocity of sea breeze due to pure S/L breeze.

Fig. 2 shows the vertical crossection of air flow and the vortex characteristics during different time period. Generally, the vortex is generated from the coastal line as in Fig. 2(b) during transition period and its size and shape also changed with the change in potential temperature and pressure differences between land and sea surface. The depth of the vortex was about 350 m at early morning around 6AM and it reached to the ultimate height of 1,000 m around 3PM. Similarly, the vortex influenced to 25~30 km and 15~20 km to land and sea side during sea breeze period and about 10~15 km and 15~20 km to land and sea during land breeze period, respectively. Hence the size of the vortex limits the breeze circulation zone that control the dispersion of air pollution around the coastal region.

References


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