

Effects of Sea Breezes on Mitigating Urban Heat Island Phenomenon : Vertical Observation Results in the Urban Center of Sendai

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**Effects of Sea Breezes on Mitigating Urban Heat Island Phenomenon:
Vertical Observation Results in the Urban Center of Sendai**

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Abstract

The mitigation of the urban heat island phenomenon by local circulations of land and sea breezes has recently become a subject of major interest. This study aims to clarify the effects of sea breezes on the urban heat island phenomenon in Sendai, Northeast Japan, paying attention to the vertical mixing effects of tall buildings.

In Sendai city, where the urban heat island phenomenon has developed along with sea breeze circulation, spatially dense observations of temperature were carried out with instrument screens at twenty-five elementary schools in and around the urban area from 2000 to 2004.

When a sea breeze begins to blow, the air temperature in the coastal region peaks and does not rise during daytime. By comparing the warming quantity during the day when sea breezes do not blow, the cooling effects of the sea breeze are evaluated quantitatively. It was found that cooling effects are remarkable in May and June, and disappear in September. Cooling effects in the urban center do not differ from those in the suburban area, in spite of dense buildings and large number of roughness parameters. Because of the mixing function, the large number of roughness parameters is considered to be useful to pull the cool air mass of sea breezes down to the ground.

Vertical observations of wind and air temperature at the Miyagi Prefectural headquarters, which is located in the central business district (CBD), were carried out from July 2007 to July 2008. When sea breezes begins to blow, downward air currents were observed at the windward walls of buildings, and the cooling effects of sea breezes were identified gradually from the tops of tall buildings to the ground. The horizontal distributions of air temperature during the day with sea breezes produce relatively cool areas near the coast and in the urban center. The cooling effects of sea breezes appear to be more remarkably in the urban center than in the residential area where there are no tall buildings.

Key words : heat island, sea breeze, mitigation effect of heat island, mixing of urban atmosphere

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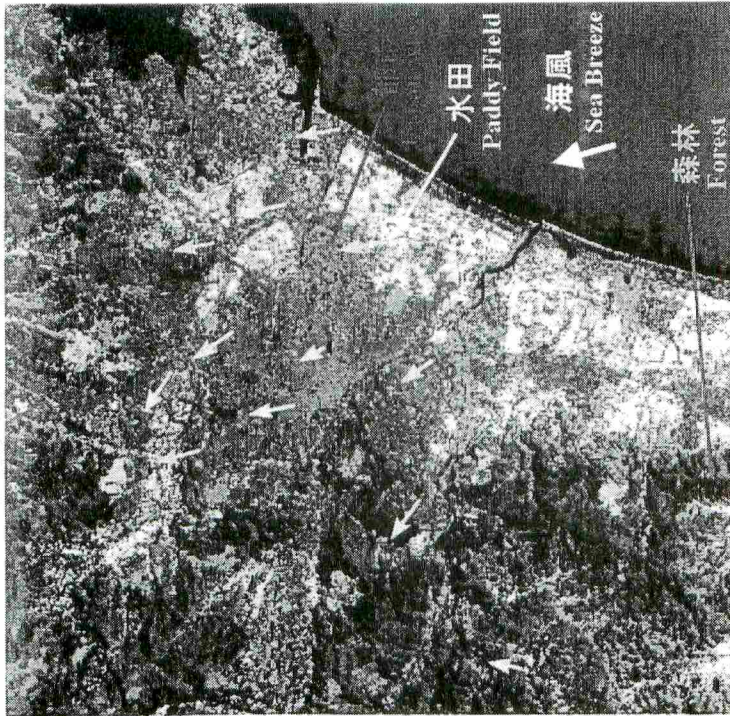


Fig. 1 Land use (2000) and sea breeze in the Sendai Plain.

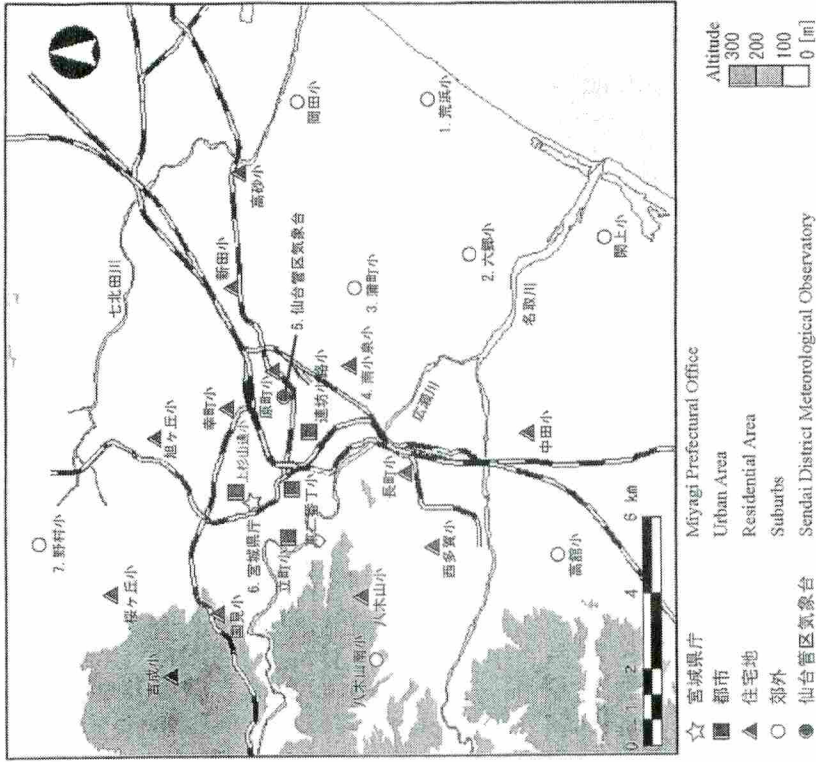
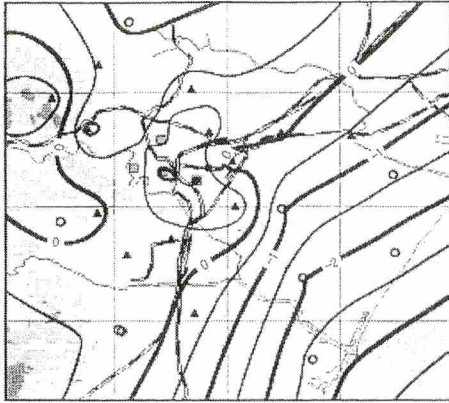


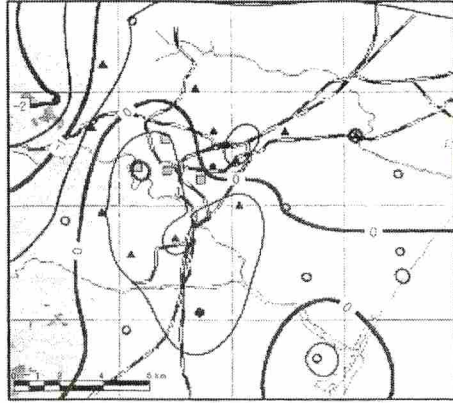
Fig. 2 Observation network in and around the Sendai urban area.

☆ Miyagi Prefecture Office, ● Sendai District Meteorological Observatory,
 □ Elementary Schools in urban center, △ Elementary Schools in residential
 area, ○ Elementary Schools in suburban area.

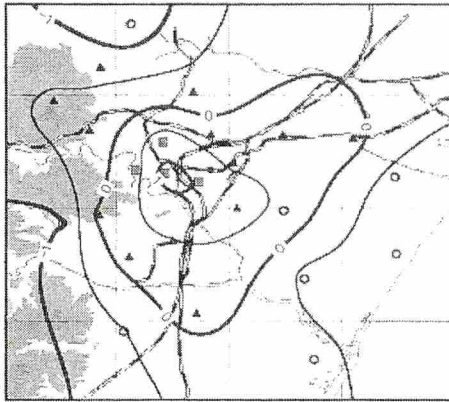
(a) 海陸風日 14時



(b) 非海陸風日 14時



(c) 海陸風日 2時



(d) 非海陸風日 2時

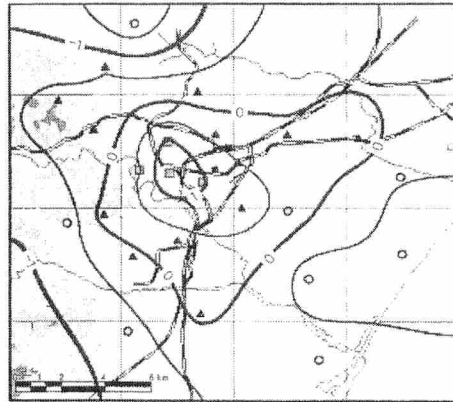


Fig. 3 Distribution of air temperature deviations in the cases of sea breeze/no sea breeze days in spring. Upper: day time (14:00), Bottom: night time (2:00), Left: land/sea breeze, Right: no land/sea breeze. Contour interval is 0.5 degree.

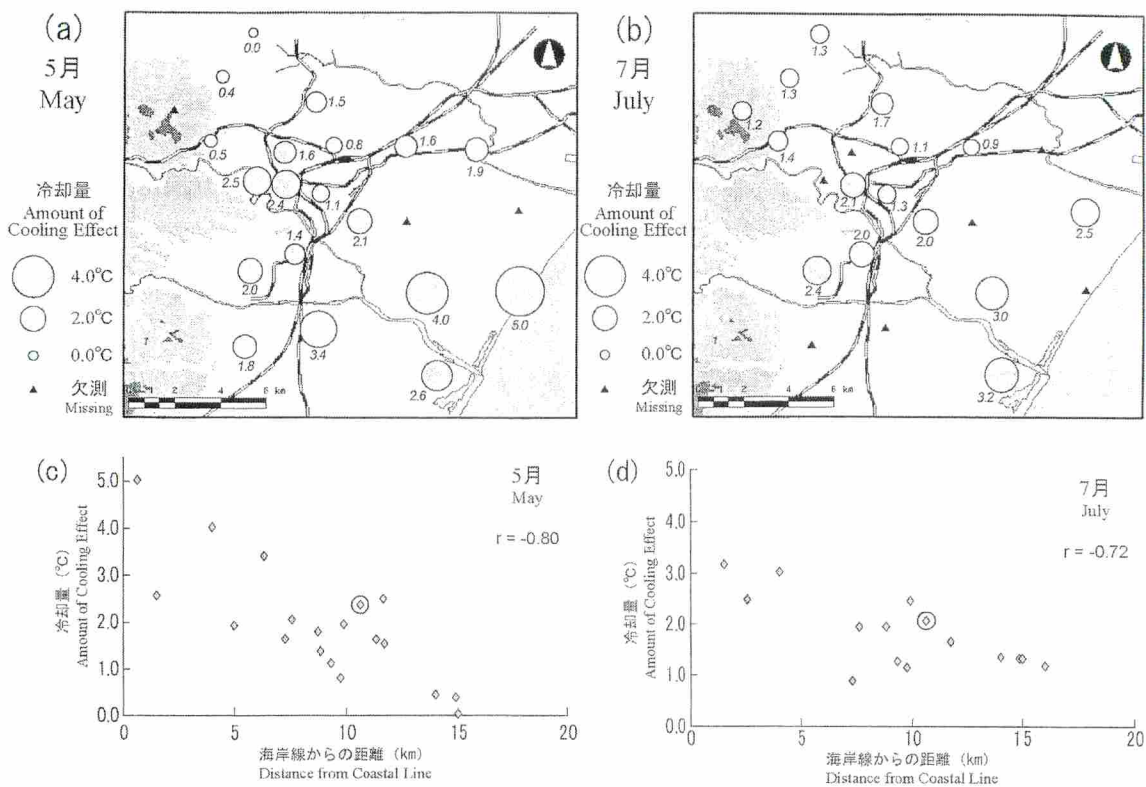


Fig. 4 Cooling effects of sea breezes.

(a) (b) Distribution of cooling effects (May, July). (c) (d) Relationship between distance from coastal line and cooling effects (May, July). Circles indicate data from elementary schools in the urban center.

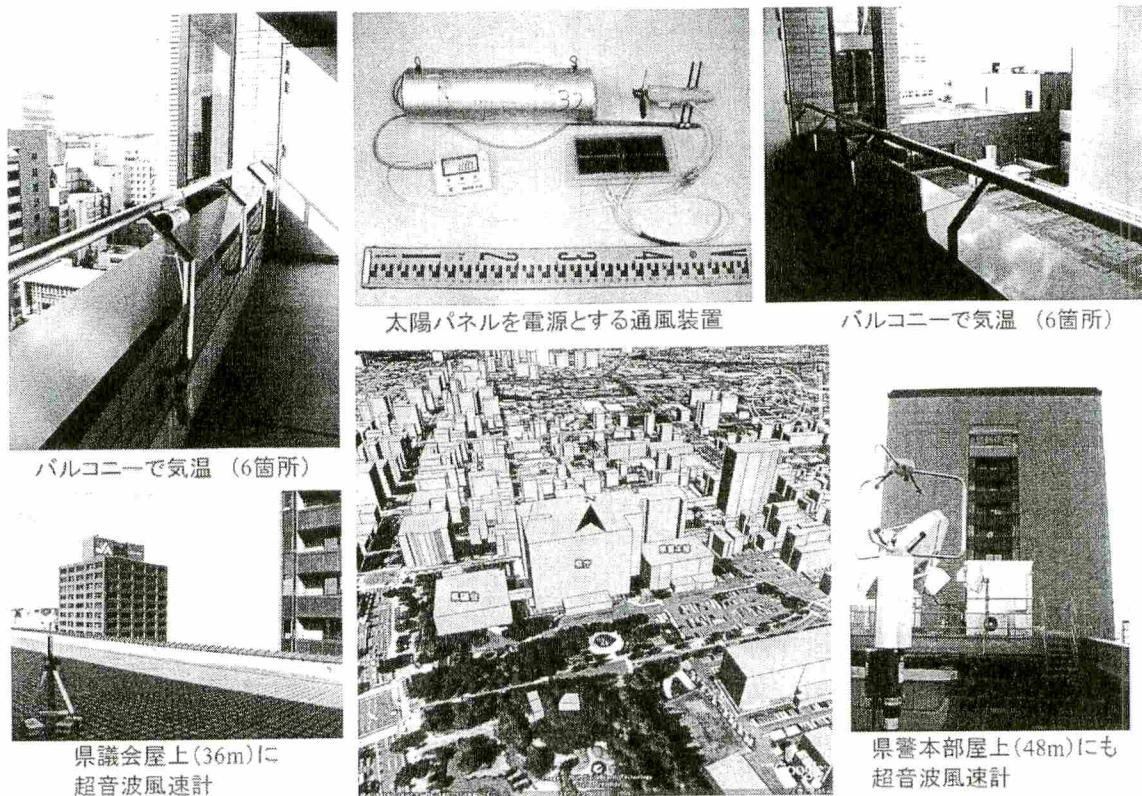


Fig. 5 Vertical observations of wind and air temperature at the Miyagi Prefectural headquarters and adjacent buildings.

Air temperatures were observed at both side balconies of the building. Wind speeds were observed on the roofs of adjacent buildings.

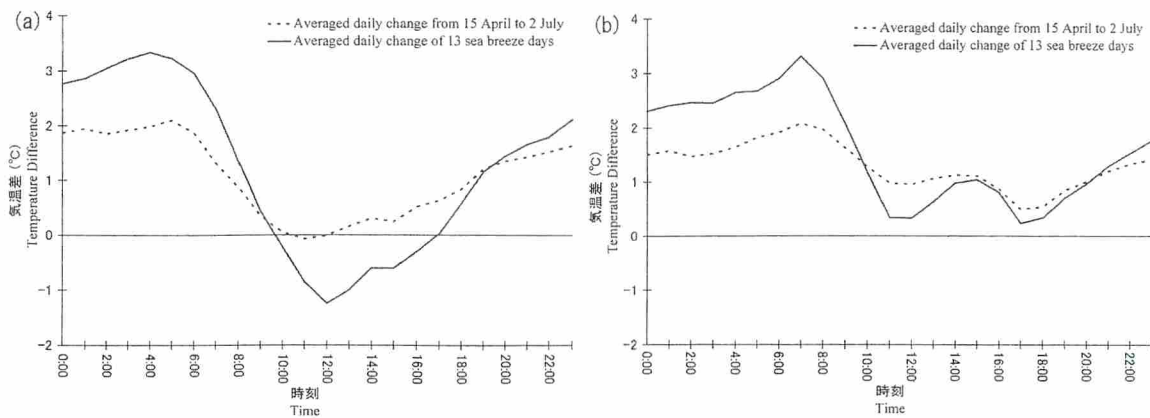


Fig. 7 Daily changes of heat island intensity (HII).

(a) HII (CBD-Rural), (b) HII (Residential area-rural). full line: land/sea breeze days, dashed line: period mean.

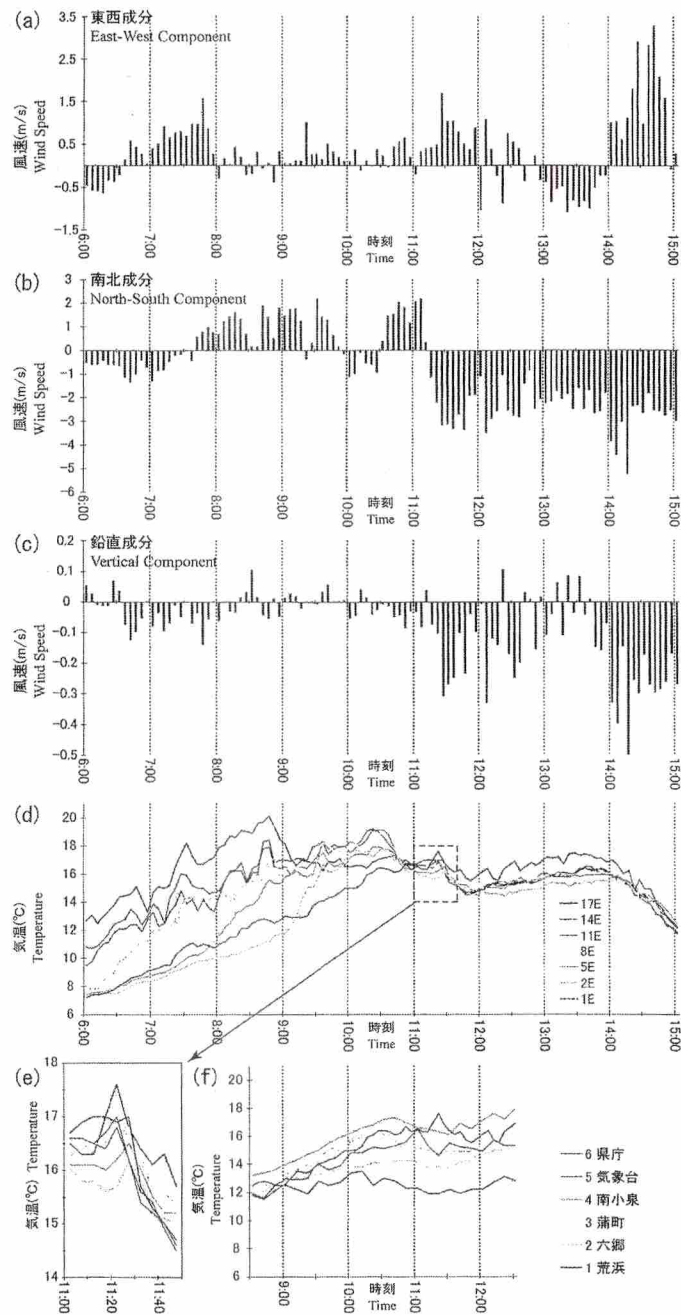


Fig. 6 Air temperatures and wind variations at the CBD area with the occurrence of sea breezes on 15th April, 2008. (a) East-west wind component on roof of eastward building. (b) North-south wind component on roof of eastward building. (c) Vertical wind component on roof of eastward building. (d) (e) Air temperatures at east side balconies of the building. (f) Air temperatures at several stations in and around the urban area.

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