한국환경과학회 봄학술발표회 발표논문집 제12권(제1호), 45 - 49, 2003
Proceedings of the Korean Environmental Sciences Society Conference, May. 16~17, 2003

OA5

Tropical Night in the Coastal Complex Terrain

Hyo Choi
Dept. of Atmos. Environ. Sci., Kangnung National University

1. Introduction

In recent years, tropical night has often occurred in summer. Pielke (1984), Choi (2003) and Palmer, Smith & Swinbank (1986). stated both orographic effects with high mountains and the roll of sea breeze on atmospheric circulations near the coast, under the horizontal temperature contrast of air over land and sea surfaces. Kondo, Kuwagata & Haginoya (1989) emphasized that more sensible heat had to be accumulated in the valley region than over the mountainous areas on calm and cloudless days, due to much larger amplitudes of the diurnal variations of atmospheric temperature and surface pressure at the bottom of a valley. Here, this study is focussed on the driving mechanisms on the formation of tropical night.

2. Numerical analysis and Data

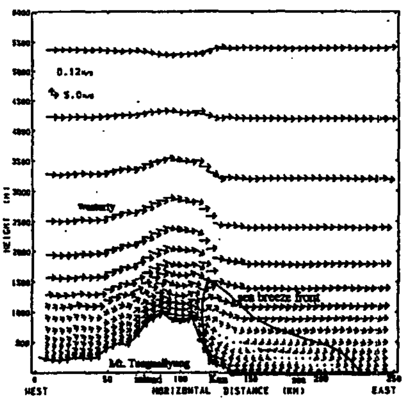
Topographical feature of the study area consists of inland plain, high steep mountains, narrow inland basin and sea. In a coarse-mesh domain, Tae Bak mountains lie from south toward north along the eastern coast of Korea and another several branch mountains stretch out toward south-west off the mountains. In a fine-mesh domain, the study area consists of complex terrains characterized by forest in a high steep mountain (Mt. Taeguallyung; 865m) in the west, Kangnung city in the narrow plain of the center and sea in the east.

A non-hydrostatic grid point model in a complex terrain-following coordinate (x, y, z*) was adopted for a 48 hour numerical experiment from 0600LST, August 13 to 0600LST, August 15, 1995, by Hitachi super computer at Japan Meteorological Research Institute (Takahashi, 1998). Two different domains consist of 50 x 50 grid points with a uniform horizontal interval as 20km in a coarse-mesh model and 5km in a fine-mesh for one- way double nesting, respectively. 16 levels in the vertical coordinate were divided from .10 m into 6 km. 12 hourly global meteorological analysis data made by Japan Meteorological Agency were horizontally and vertically interpolated for initial data in the coarse domain and predicted ones by the model were treated as lateral boundary data in the fine-mesh. National Oceanic and Atmospheric Administration satellite pictures were used.

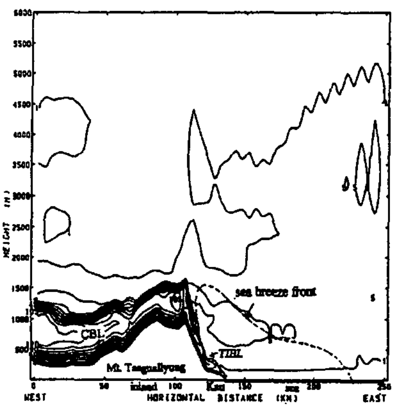
3. Result

As synoptic scale westerly wind blowing over a high steep mountain in the west of a city toward the eastern sea is interrupted by upslope wind combined with valley wind and easterly sea breeze from the sea, two different wind regimes confront near the mid of the eastern slope of the mountain and go up to the 1700 m height over the ground, becoming a westerly return flow in the upper level over the sea. Convective boundary layer (CBL) with a 1km depth is developed over the ground surface of the inland basin in the west of the mountain, while a depth of thermal internal boundary layer (TIBL) like CBL shrunken by relatively cool easterly sea-breeze is less than 150 m from the coast along the eastern slope of the mountain and the TIBL extends up to the height of 1700m parallel to upslope wind.

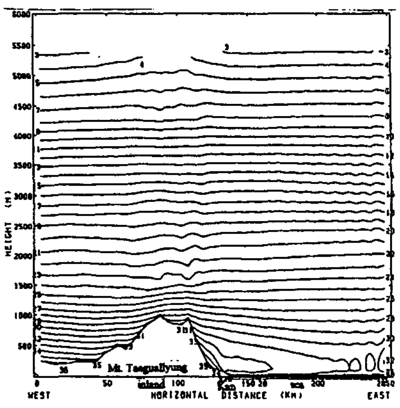
As sensible heat flux convergences between the ground surface of the mountain or inland coast and upper level atmosphere over the surface are much greater than the flux on the coastal sea, the flux should be accumulated inside the TIBL along the mountain slope and the CBL over the mountain top. Then, accumulated sensible heat flux under the influence of sea breeze circulation returning from the mountain top toward the coastal surface should be transported into the coast, resulting in high air temperatures in the coastal inland and sea (Fig. 1).



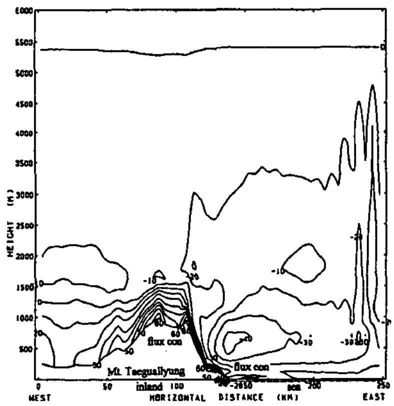
a



b



c

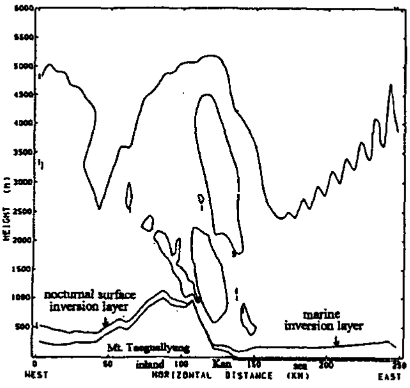


d

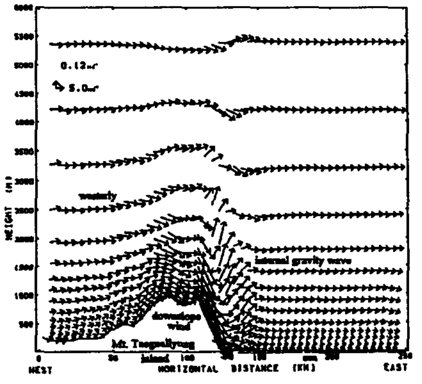
Fig. 1. (a) Vertical profiles of wind (m/s), (b) turbulence diffusion coefficient (m/s^2), (c) air temperature (^0C) and (d) sensible heat flux (W/m^2) at 1200LST, August 14, 1995.

As latent heat flux convergence from the inland coastal surface into the upper level is greater than one from the mountain top toward the atmosphere, some water vapor evaporated from the coastal surface was transported from the coast into the mountain top and relative humidity is low at the coast and high over the mountain top.

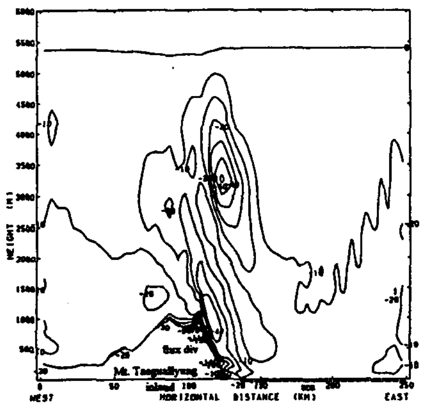
Under nocturnal cooling of ground surface after sunset, mountain wind with the daytime existed westerly wind to be an intensified westerly downslope wind and it further combined with land breeze, becoming strong wind. No sensible heat flux divergence or very small flux divergence occurs in the coast, but the flux divergences are much greater at the top of the mountain and along its eastern slope than over the coastal inland and sea surfaces (Fig. 2). By more cooling down of the mountain surface than the coastal surface and heat transfer from warm pool over the coast into the coastal surface, nocturnal air temperature on the sea and coastal inland surfaces are not much changed from daytime ones. Latent heat flux near the coastal surface has the same magnitude in the lower atmosphere and no latent heat flux divergence exists at the coast. Thus, it induces high relative humidity along the slope of the mountain or the inland, but low relative humidity at the coast.



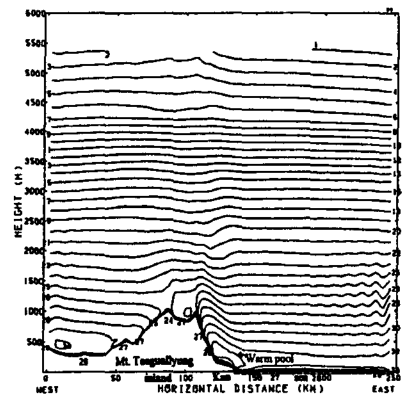
a



b



c



d

Fig. 2. (a) Vertical profiles of wind (m/s), (b) turbulence diffusion coefficient (m/s^2), (c) air temperature (^0C) and (d) sensible heat flux (W/m^2) at 0000LST, August 15, 1995.

4. Conclusion

As the convergence of sensible heat flux from the ground surface of mountain (or inland coast) toward upper level atmosphere is much greater than the flux on the coastal sea, sensible heat flux should be accumulated inside thermal internal boundary layer along the eastern slope of the mountain and convective boundary layer over the top of the mountain. Then, accumulated sensible heat flux under the influence of sea breeze returning from the mountain top toward the coast was transported into the coast, resulting in high air temperature. At night, mountain wind was an intensified westerly downslope wind and it further combined with land breeze, becoming strong wind. Very small sensible heat flux divergence occured in the coast and coastal sea, but flux divergences are very big at the mountain slope. Much more cooling down of the mountain surface than the coastal surface and heat transfer from warm pool over the coast toward the coast resulted in tropical night.

Reference

Choi, H., Increase of ozone concentration in an inland basin during the period of nocturnal thermal high. Water, Air & Soil Pollution: Focuss, under press, 2003.

Kondo, J., Kuwagata, T. & Haginoya, S., Heat budget analysis of nocturnal cooling and daytime heating in a basin. Journal of Atmospheric Sciences, 46, 2917-2933, 1989.

Palmer, T. N.,Smith, G. J. & Swinbank, R., Alleviation of a systematic westerly bias in general circulation and NWP models through and orographic gravity wave drag parameterization. Quarterly Journal of Royal Meteorological Society, 112, 1001-1039, 1986.

Pielke, R. A., Mesoscale meteorological modeling. Academic Press, 612 pp, 1984.

Takahashi, S., Manual of LAS model revised by Dr. J. Sato, 50pp. 1998.