한국환경과학회 봄 학술발표회 발표논문집 제11권(제1호), 317 - 320, 2002
Proceedings of the Korean Environmental Sciences Society Conference, May. 24~25, 2002

해양환경-7

Possibility of ocean pollution by air pollutant transport

Hyo Choi*
Dept. of Atmospheric Environmental Sciences,
Kangnung National University

1. Introduction

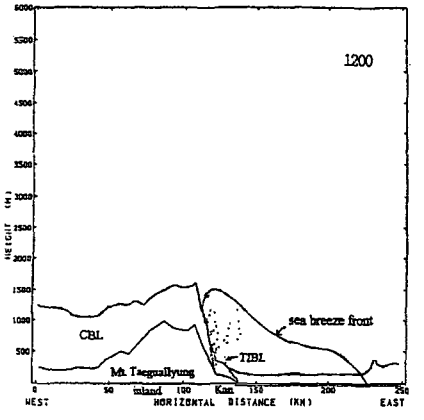
Effects of both atmospheric circulation and boundary layer forcing on the diurnal variation of suspended particulate concentration in the mountainous coastal city and sea, here are investigated by meteorological and pollution models (Carmichael et al., 1991).

2. Method

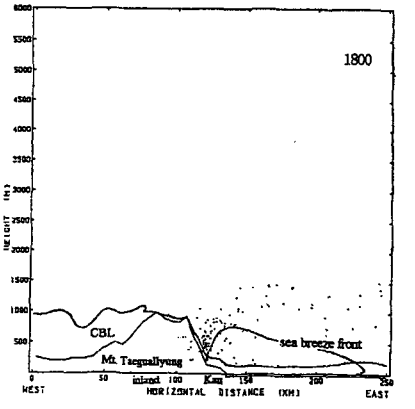
Firstly, as meteorological models-non hydrostatic and hydrostatic models in a complex terrain-following coordinate (x, y, z^*) were adopted for a 48 hour numerical experiment from August 13 to 15, 1995, by Hitachi super computer at Meteorological Research Institute. Two different domains consist of 50x50 grid points with a 20km of horizontal interval in a coarse-mesh domain with hydrostatic model and 5km in a fine-mesh with non-hydrostatic model, whose vertical coordinate was divided into 15 levels from 10m into 6km. Three-dimensional Random Walk Model was adopted for tracing lagrangian motions of pollutants, through transforming the z^* coordinate in non-hydrostatic model for wind and turbulence fields into the z+ coordinate.

3. Result and discussion

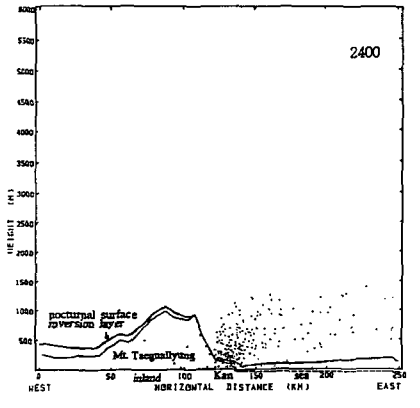
During the day, on August 14, 1995, convective boundary layer (CBL) is developed with a thickness of about 1500m over the ground in the upwind side of Mt Taegullyung, in the west of a coastal plain (Kangnung), but a thickness of thermal internal boundary layer (TIBL) along the eastern slope is only confined to about 100m, below an easterly sea-breeze circulation.



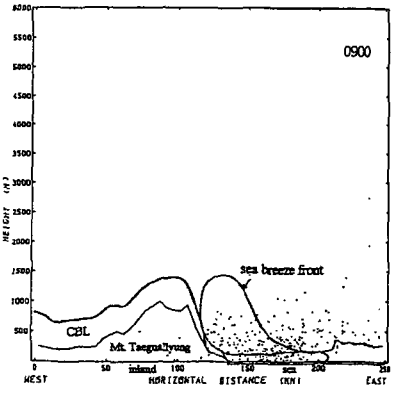
(a)



(b)



(c)



(d)

Fig. 1. Transport of particulates near Mt. Taegullyung (left), Kangnung city (center)-the East Sea (right) at 1200LST on August 13, 1995. Particulates go up to the 1,400m under upslope wind and sea-breeze (a). Near sunset (1800LST), the TIBL thickness and sea-breeze become smaller and the floating heights of particulates are much lower than at 1200LST (b). Particulates move down into Kangnung, showing the maximum TSP concentration at 2400LST (c). On the next day (0900LST), easterly sea-breeze drived some of particulates into the East Sea at night to come back from the sea into the city (d).

So, upslope wind-both valley wind from the inland plain toward the mountain top and easterly sea breeze from coastal sea toward the plain, goes up to 1500m height. The upslope wind interrupts westerly wind over the mountain top and then, westerly return flow is toward the East Sea.

Suspended particulate matters released from Kangnung float under the development of the TIBL and go up along the eastern slope of the mountain, reaching the top of the CBL. Then, they are dispersed eastward in the upper layer, below the height of sea-breeze circulation and widely spread out over the coastal sea. Thus, daytime ground level-concentration of total suspended particulate matters (TSP) in the downtown is low and becomes higher, closing to sunset time.

After sunset, radiative cooling of the ground surface produces a shallow nocturnal surface inversion layer (NSIL) with a 200m in the inland. Synoptic westerly wind over the mountain top should be intensified by downslope wind (mountain wind) blowing from the mountain top toward Kangnung and it is also associated with land-breeze from Kangnung toward the East Sea, becoming stronger. This strong downslope wind bounds up toward the upper level with a hydraulic jump motion, showing the development of internal gravity waves in the eastern side.

Since this westerly downslope wind penetrates into Kangnung city, both daytime floated particles and nighttime emitted ones from the ground move down along the eastern slope of the mountain and toward the downtown of the coastal city, confining within shallow NSIL. Finally, as they further go toward the sea, a maximum ground level concentration at the city is shown at 2400LST.

Now, we can investigate the possibility of sea water pollution by the transportation of air pollutants. The particulates or gasses, which previously floated for daytime hours move down toward the downtown area and these pollutants combined with the continuously emmitted pollutants from the ground surface of the city, producing the high concentration of suspended particulate matters on the ground level. From 2400LST, air pollutants really reach coastal sea and most of pollutants merges into the sea surface and can be melted by sea waters, resulting in the possibility of sea water pollution. Later, the pollutants reached on the sea surface absorb waters and are melted by sea water, and then, they should sink to the sea-bed. the sunken pollutant materials can cause secondary pollution of sea-bed, because the sunken pollutants are oilly materials and overspread the sand-clay of sea-bed, finally resulting in the depth of sea feed and shellfish.

Especially, majority of particles in the NSIL at the coast are dispersed toward the propagation area of internal gravity waves in the upper level over the sea, showing a different pattern from common one and also high concentration on the sea surface.

At 0900LST, on the next day, some of the nighttime dispersed particles return from the sea to the inland under easterly sea breeze and the sea water pollution on the sea surface still continue to be, until the disappearance of pollutants over sea surface. Emitted particulate from the surface of the downtown area and returned pollutants from the sea altogether float again, moving to the mountain and finally showing recycling of particulate matters.

Acknowledgement

This research is supported by a grant-in-aid for Dual use technology. "Virtual marine environmental analysis technology for systematic operation-verification and prediction of marine wind through marine observation in 1999-2002" from Ministry of Science & Technology.

References

Carmichael, G. R., Peters, L. K. and Saylor, R. D., (1991). The STEM-II regional scales acid deposition and photochemical oxidant model-I. Atmos. Environ., 30, 2407-2090.