A case study of vertical wind fields over Tokyo associated with sea breeze circulation by use of a Doppler lidar and the WRF model

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In the Kanto Plain, the extended sea breeze originating from the Pacific Ocean frequently prevails on summer sunny days with weak synoptic wind condition. The sea breeze is, therefore, quite familiar to people living in the Tokyo metropolitan area.

To observe horizontal and vertical wind fields over Tokyo associated with the sea breeze circulation, ground-based Doppler lidar observations were conducted at the National Institute of Information and Communications Technology (NICT) headquarters, which is located at Koganei, Tokyo. The Doppler lidar system was developed at NICT.

The present study analyzed results of the Doppler lidar observations performed on August 10, 2006 through meteorological analyses and numerical simulations by use of the advanced research version of Weather Research and Forecasting (WRF) model.

Results of the meteorological analyses of data from a fine surface observation network and the numerical simulations showed that the southerly sea breezes originating from Sagami Bay and Tokyo Bay penetrated into inland on the early afternoon of August 10. Satellite images by the Moderate Resolution Imaging Spectroradiometer (MODIS) showed cumulus cloud bands extending along the sea breeze fronts. The Doppler lidar detected part of the cloud band and strong updrafts when the sea breeze front passed the observation site. A ceilometer and a wind profiler installed in the same observation site also observed the clouds and updrafts, respectively.

After the passage of the sea breeze front, vertical wind fields over Tokyo had a sharp multi-layered structure. The multi-layered wind structure was composed of 1) the sea breeze layer at altitudes below 0.8 km above mean sea level (MSL), 2) a layer of weak winds at altitudes of 0.8-1.2 km MSL, 3) the compensatory return flow layer at altitudes of 1.2-2 km MSL, and 4) a prevailing synoptic wind at altitudes above 2 km MSL. This wind structure, which was not clearly shown by many previous observations by use of piballs and radiosondes, might influence the movement and development of thunderclouds and convective precipitation that frequently appear over Tokyo on summer days.