STUDY OF ATMOSPHERIC BOUNDARY LAYER OVER HONG KONG USING MOBILE MICRO-PULSE LIDAR

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Study of Atmospheric Boundary Layer over Hong Kong Using Mobile Micro-Pulse Lidar
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Abstract

Study of the boundary layer height, also known as the mixed layer height or mixing height, is of most importance to air pollution research and numerical modelling. In order to measure the mixing heights at various locations in Hong Kong, an eye-safe mobile micro-pulse lidar has been developed and deployed in field campaigns. In this thesis, the principle of lidar operation and our eye-safe mobile micro-pulse lidar design are introduced. These mobile lidar measurements are the first of their kind in Hong Kong. The advantages and limitations of using mobile lidar for mixing height determination are studied and discussed. To investigate the seasonal variation as well as the difference in mixing height at different locations, one-year periodic measurements were made at four selected sites located at the extreme edges of Hong Kong for a collaboration project with the Environmental Protection Department (EPD) during year 2003. The results show that there is a general seasonal trend of the daily maximum mixing height (MMH) among the sites. The MMH was found to be related to the temperature, wind speed and relative humidity of the atmosphere. For example, the MMH in autumn is generally the highest because of warm and dry conditions. The seasonal trend at one particular site is inconsistent with the general trend, and it will be explained in detail. Diurnal variations of the mixing height were observed and analysed with reference to meteorological parameters provided by the Hong Kong Observatory (HKO). Strong correlation between the diurnal variation and the temperature change was found. To verify our lidar data, comparisons were made with radiosonde data provided by the HKO. In addition, a road trip campaign was conducted at eight selected sites in the New Territories region of Hong Kong along a major highway during 2004 and 2005 and the results are presented.

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Symbols and Acronyms

α	extinction coefficient
α_A	fraction of active cloud coverage
β	backscatter coefficient
λ	wavelength
η	net volumetric flow rate
ρ	density of the fluid
θ	potential temperature
τ	optical thickness
μ	magnetic permeability
σ	standard deviation
σ_r	Rayleigh scattering cross-section
σ_m	Mie scattering cross-section
$\overline{w'\theta_s'}$	the sensible heat flux on the earth's surface
A	absorption coefficient
a	radius of the scattering particle
A_e	effective system receiver area
C	the calibration constant of the lidar setup
c	the velocity of light
E	laser pulse energy
e	vapour pressure
e_s	saturated vapour pressure
h_n	spherical Hankel functions
I	intensity of radiation

I_o	initial intensity of the radiation before entering the media
j_n	spherical Bessel functions
k	the wavenumber
L_v	specific latent heat of vaporization at 0°C
m	ratio of the refractive index of the particle to that of the surrounding medium
P	received power of the lidar
p	pressure
p_o	ground level pressure
R_v	specific gas constant for water vapour
r	range
Δr	range error of the lidar setup
δr	range resolution of the lidar setup
S	logarithmic range adjusted power variable
S_1	lidar ratio (equal to BER)
T	temperature
T_o	ground level temperature
T_d	dew point temperature
t	travelling time of laser pulse
t'	difference in the travelling time of laser pulse
δt	time resolution of the lidar setup
Δt	time error of the lidar setup
u	flow velocity
w_i	weighting factor of averaging
w_c	the average vertical velocity within the clouds

w_e	entrainment velocity
w_L	the mean large-scale vertical motion
z	distance of the radiation travelled in a medium
ABL	Atmospheric Boundary Layer
BP	Black Point (lidar measurement site)
CBL	Convective Boundary Layer
CityU	City University of Hong Kong
DBL	Diurnal Boundary Layer
EPD	Environmental Protection Department (H.K.)
EZ	Entrainment Zone
HH	Hoi Ha (lidar measurement site)
HKO	Hong Kong Observatory
HT	Hok Tsui (lidar measurement site)
LCL	Lifting Condensation Level
Lidar	Light Detection and Ranging
ML	Mixing Layer
MMH	Maximum Mixing Height
MPE	Maximum Permissible Exposure
MPL	Micro Pulse Lidar
NBL	Nocturnal Boundary Layer
NT	The New Territories of Hong Kong
PBL	Planetary Boundary Layer
PMT	Photo Multiplier Tube
Radar	Radiation Detection And Ranging
RL	Residual Layer

RTE	Radiative Transfer Equations
SBL	Stable Boundary Layer
Sodar	Sound Detection And Ranging
TBT	Tsim Bei Tsui (lidar measurement site)