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ORIGINAL PAPER

Full scale plume rise modeling in calm and low wind velocity conditions

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Abstract A variety of models and software products are in use for computer simulation of pollutant dispersion for air pollution assessment. All of them need to calculate the so called *effective stack height*, but problems are encountered in calm and low wind velocity conditions. The present research aims at such meteorological situations.

Based on a full scale numerical simulation, the plume rise has been investigated in sub-adiabatic and near-adiabatic conditions. The influence of the emission and stack parameters, the ground level air temperature, the temperature gradient of the atmosphere, and the surface wind velocity in the range from 0.0 to 1.0 m/s is studied.

A computational fluid dynamics problem has been formulated and solved for planned combinations of meteorological conditions and emission parameters. For each numerical simulation the height of the plume center line and hence, the plume rise has been assessed. The results obtained have been used to work out new mathematical models for plume rise calculation.

Keywords Air pollution · Full scale · Plume rise · Calm weather · Low wind velocity · Mathematical modeling

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List of symbols

C	Pollutant concentration (mg/m^3)
D_s	Stack diameter (m)
E	Error of prediction (m)
F_e	Emission flow rate (m^3/s)
g	Gravitational acceleration (m/s^2)
H_{ef}	Effective stack height (m)
H_s	Stack height (m)
h	Distance from the ground (m)
h_{ref}	Reference height (m)
K	Exchange coefficient (kg/(m^{2}s))
N	Brunt–Väisälä frequency (s^{-1})
P	Pressure (Pa)
P_g	Ground level pressure (Pa)
R	Gas constant
r_s	Stack radius (m)
S	Source
T	Temperature (K)
T_a	Ambient air temperature (K)
T_0	Ground level air temperature (K)
T_s	Stack gas temperature (K)
U	Wind velocity (m/s)
u	Velocity in horizontal, perpendicular to the wind direction (m/s)
V	Velocity vector (m/s)
v	Vertical velocity (m/s)
v_s	Stack gas vertical velocity (m/s)
w	Velocity in the wind direction (m/s)
w_{ref}	Reference wind velocity
w_{top}	Wind velocity at the stack top level (m/s)
x	Down wind distance from the stack (m)
Γ	Adiabatic lapse rate (K/m)
Δh	Plume rise (m)
ρ	Density (kg/m^3)
ρ_a	Ambient air density (kg/m^3)

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