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A Note on the Estimation of Eddy Diffusivity and Dissipation Length in Low Winds over a Tropical Urban Terrain

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Abstract — Urban terrain poses a challenge for modeling air pollutant diffusion. In tropics, because of the dominant low wind speed environment, the importance of understanding the turbulence diffusion is even more critical, and uncertain. The objective of this study is to estimate the vertical eddy diffusivity of an urban, tropical atmosphere in low–wind speeds. Turbulence measurements at 1 Hz were made at 4-m level over an urban terrain with a roughness length of 0.78 m during winter months. Eddy diffusivity is estimated from spectral quantities of the turbulence data involving turbulent kinetic energy (E) and its dissipation rate (ε). The spectral information of the vertical velocity fluctuations is used to estimate the vertical length scale which provides information on the eddy diffusivity. In addition, the product of friction velocity and the vertical length scale has been used to non-dimensionalize the eddy diffusivity, which is shown to increase with increasing instability. Using the eddy diffusivity (K) estimates from the $E - \varepsilon$ approach, a relation is suggested for the mixing length based eddy diffusivity models of the form: $K = c_w.[2.5 - 0.5(z/L)]$, where z is the measurement height, L is the Obukhov length, and c_w has an average value close to 1 for unstable and near 0.5 for stable conditions for the urban terrains.

Key words: Air quality, atmospheric boundary layer, dissipation length, eddy diffusivity, tropics, urban terrain.

Introduction

Eddy diffusivity is an important variable for planetary boundary layer (PBL) parameterizations. It is used as a dimensional parameter in turbulence schemes. Following the Fickian diffusion, turbulent energy flux is assumed to flow down the gradient (Stull, 1988). In various environmental applications, there is a need to predict eddy diffusivity from knowledge of turbulence, for which the idea of quantifying vertical mixing from the spectral quantities is a viable approach (Lee, 1996).

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