Two issues relating to the CFD modelling of pollution dispersion under neutral conditions

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This paper discusses two distinct issues that face modellers when using Computational Fluid Dynamics (CFD) to model the airborne dispersion of pollutants. Whether this be in open flat terrain or complex urban environments, the problem of specifying an appropriate turbulent Prandtl number is one which has been addressed by a number of researchers. Tominaga and Stathopoulos (2007) consider a wide range of dispersion studies that employ CFD, concentrating on the value of the turbulent Schmidt number, Sc_t, under a range of conditions. They found, for example, that for open country dispersion, a value of Sc_t of approximately 0.3 was appropriate – due to the fact that turbulent momentum diffusion is underestimated in RANS models in these cases. They suggested that the turbulent Schmidt number be based on the dominant flow structure in each case. More recently, Chavez et al. (2011) have assessed the influence of the turbulent Schmidt number on a small cluster of isolated buildings. They found that in some configurations, the predicted concentrations were sensitive to the turbulent Schmidt number, while in others it was not.

An appreciation of the averaging period of the experimental data against which steady–state Reynolds–Averaged Navier–Stokes (RANS) solutions are compared is often lacking. In many studies, little mention is made of the averaging period used in the wind tunnel or full–scale experiments, which is used to obtain the mean concentration values used in the comparison with the CFD simulations. Chavez et al. (2011) do mention that in the wind tunnel an averaging time of 1 minute was used, which they argued was equivalent to 1 hour full–scale, based on the earlier findings of Stathopoulos et al. (2004). The familiar graphical representations of σ_y and σ_z of Turner (1970) are used extensively in undergraduate teaching programs and in many Gaussian plume models. However, they are based on a application of theory to the analysis of actual dispersion data obtained over level, open terrain. More significantly, they were constructed from 10 minute averaging periods.

The paper opens with a discussion of these two issues in turn and then goes on to provide a route, via a number of numerical experiments, to possible solutions to these vexing issues. The cases considered are: dispersion in a uniform turbulent flow; dispersion in a neutral ABL; dispersion and plume rise in a neutral ABL; and dispersion around an isolated cubic building.

References

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