RECENT ADVANCES OF THE FLOW AND DISPERSAL MODEL MISCAM: MODEL DEVELOPMENT AND EVALUATION

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INTRODUCTION

The numerical flow and dispersal model MISCAM is widely-used by meteorological consultants, environmental protection agencies as well as universities to simulate microscale flow fields as well as pollutant dispersal in the vicinity of buildings or within street canyons.
Within the last few years, a couple of model extensions has been implemented and, in part, evaluated. The current study summarises the most important new features of MISCAM which have already been distributed to users or will be included within the next release version. Apart from a variety of small technical improvements, the following modifications of MISCAM will be discussed:

1. MISCAM is now capable to simulate flow through tall vegetation, which is modelled in terms of stand density, leaf area density and some empirical drag coefficients.
2. MISCAM allows pollutants to be emitted with a prescribed vertical velocity. This velocity is accounted for during the computation of flow and turbulence fields, giving a more realistic image of flow properties e.g. near industrial stacks.
3. Advection of momentum and turbulence quantities can now be handled in a more flexible way, using schemes with significantly lower numerical diffusion than the upstream scheme. The effects of the refined treatment of advection are examined by stepping through the evaluation process as proposed by the VDI guideline 3783/9 'Prognostic microscale wind field models – Evaluation for flow around buildings and obstacles'
4. A new initialisation procedure has been implemented to account for non-resolved building structures outside the inner model domain. By introducing a displacement height into the inflow wind profiles, it is possible to significantly reduce the horizontal extension of the domain, thus saving disk space as well as CPU time. A quantitative evaluation of results for complex urban situations is in progress.

FLOW THROUGH TALL VEGETATION

The model has been extended to account for effects of vegetation on wind speed, turbulence production as well as dissipation of turbulent kinetic energy. These effects enter the prognostic equations in terms of an additional drag force, yielding a retardation of the flow due to friction on leaf surfaces, as well as source terms in the turbulence equations. The parameterisation is carried out according to *Green, S.R.* (1992).

Results have been compared to measured wind data obtained from high resolution measurements within a single tree crown (see *Lauerbach, H. and J. Eichhorn*, 2004). The model successfully simulates small scale variabilities of the model variables due to local changes of leaf area density. The quantitative agreement between simulations and observations, however, is not yet satisfactory.

REFINED TREATMENT OF POLLUTANT SOURCES

Formerly, pollutant sources where handled as passive volume sources, i.e. at each time step the same amount of a polluting gas was added to the mass concentration within the corresponding grid cells.

A refined treatment of point sources, like emissions from tall stacks, has been introduced by *Eichhorn, J.* (2003). Now, a constant exit velocity can be accounted for already during the flow simulations. This exit velocity is kept constant throughout the stack, thus, together with the horizontal wind components vanishing within the stack, mass conservation is ensured. The stack acts like a momentum source, resulting in modifications of the local wind and tubulence field in the vicinity of the stack exit. Simulations show a realistic vertical displacement of pollutant plumes depending on the ratio of exit velocity and external wind velocity.

IMPROVEMENT OF NUMERICAL SCHEMES

To keep the model small and fast enough to run on standard PC, a simple upstream scheme has formerly been implemented to solve the advection equations for momentum and turbulence quantities. This scheme's accuracy is known to suffer from excessive numerical diffusion. Therefore, the model now allows the use of a predictor-corrector scheme (*MacCormack, R.W.*, 1969) in the equations of motion. This scheme still needs a moderate amount of computing resources but performs far better as far as numerical diffusion is concernded. Additionally, for the advection of scalars (turbulence kinetic energy, dissipation) a less diffusive scheme (*Smolarkiewicz, P.K. and W.W. Grabowski*, 1989) may optionally be used.

The question, if the additional computational effort results in an adequate improvement of results, is adressed by applying a new evaluation guideline (*VDI*, 2003) to both, the simple and extended model versions (*Eichhorn, J. and A.K. Kniffka*, 2005a,b).

INFLUENCE OF NON-RESOLVED BUILDING STRUCTURES

Formerly, the only way to take into account the influence of surface properties on inflow wind profiles was an adjustment of the roughness length z_0. Higher values of z_0 imply a stronger frictional retardation of the flow near the ground, giving a modified but still logarithmic wind profile for neutral conditions. This concept, however, is not suitable due to a couple of reasons.

First, measurements within urban areas as well as wind tunnel studies show a different behaviour of the wind profile, with smaller values near the surface and an elevated logarithmic profile above building height. Second, values for z_0 cannot be chosen arbitrarily but are limited by the vertical grid resolution.

A more established method to account for surrounding buildings has been implemented instead (*Eichhorn, J. and M. Stockhause*, 2005). A zero plane displacement height d_0 is computed from parameters characterising the building structures upwind of the model domain. Tentatively, d_0 is specified depending on building height H only, using d_0=0.5H or d_0=0.8H for sparsely and densely built-up terrain, respectively. A more comprehensive treatment of d_0, adopting the suggestions of *Grimmond, S. and T. Oke* (1999) is planned for the next release of MISCAM.

Using this displacement height the initial wind profile is computed diagnostically, by matching of a log-profile below and an elevated profile above d_0. For the time being, this procedure is applicable for neutral stratification only, since no stability functions are included yet. While mechanical effects of buildings dominate thermal effects within densely built-up urban regions, this limitation is tolerable for practical applications.

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