13.4 A CFD-GENERATED WIND FIELD LIBRARY FEASIBILITY STUDY: MAXIMUM WIND DIRECTION INTERVAL

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1. INTRODUCTION

Computational fluid dynamics (CFD) models are capable of computing 3D flow patterns around arbitrary building arrangements and have shown promise for building-to-urban scale transport and dispersion problems (e.g., Murakami, 1997; Brown et al., 2001). However, their utility for planning and assessment applications has been limited due to computational requirements, expertise requisites, and relatively long turn-around time. The possibility of using a library of pre-computed mean wind and turbulence fields for a prescribed urban site has been suggested as a way of circumventing the usual complaints, while simultaneously providing more detailed and accurate information to planners than simpler urban dispersion models. In this paper, we will present a first step in evaluating whether or not this approach is feasible, i.e., examine the computing and storage requirements to build a wind library. To populate such a database, one needs to specify the prevailing wind direction interval. Using Lower Manhattan as a test case, we will try to determine the wind direction interval required to adequately describe flow patterns in a downtown area for transport and dispersion problems.

2. MODEL DESCRIPTION

For this study, we are using the HIGRAD CFD/ meteorological code that has been under development at Los Alamos National Laboratory for the DOE Chemical and Biological National Security Program. The "High Gradient" model solves the 3D compressible form of the geo-physical fluid flow equations. Turbulence closure is accomplished using a Smagorinsky-type large-eddy simulation (LES) scheme. The code solves a surface energy budget equation and includes shading effects (Smith et al., 2001).

3. PROBLEM DESCRIPTION

The model domain includes a 2 km by 2 km section of lower Manhattan with a 10 m horizontal grid size (Fig. 1). The domain extends 800 m in the vertical with an expanding vertical grid mesh (minimum dz=2 m). Inflow conditions were described by a uniform velocity profile of 2.0 m s^{-1} and neutral stability. Simulations were carried out for prevailing wind directions of 285° and 300°, values close to climatological norms.

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4. RESULTS

Figure 2 shows the wind vectors and wind speed contours computed for the 300° wind case. Wind speed and direction within the lower Manhattan area is greatly influenced by the complex arrangement of buildings and street canyons. The Manhattan skyline also has a profound influence on the overall airflow patterns surrounding the city.

Wind direction and speed differences for the 285° and 300° cases are shown in Fig. 3. The differences between the wind directions and speeds tend to be small within the lower Manhattan urban area. The largest differences tend to occur at the eastern outskirts (leeward side) of lower Manhattan. Further simulations examining a greater range of direction must be completed before any concrete conclusions can be made.

5. DISCUSSION

We found in this simple, cursory, examination that a 15° wind direction interval may be adequate for the interior of lower Manhattan. For this case, we suspect that wind direction sensitivity may be different for prevailing winds parallel to the street network versus those that are at oblique angles. A complete feasibility study must examine wind field and dispersion effects for different ambient wind speeds, a greater range of wind directions, and varying stability conditions. In this presentation, we have merely illustrated the basic concept of using a wind field library. We also expect that different cities may require different wind direction intervals. Finally, other factors such as building density,

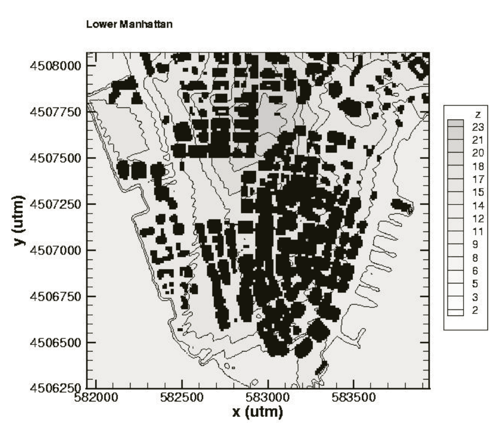

Figure 1. The model domain for lower Manhattan, including building footprints and topography. The area is a 2 Km by 2 Km square region. The Island is rotated counter-clockwise by 30 degrees in this figure.

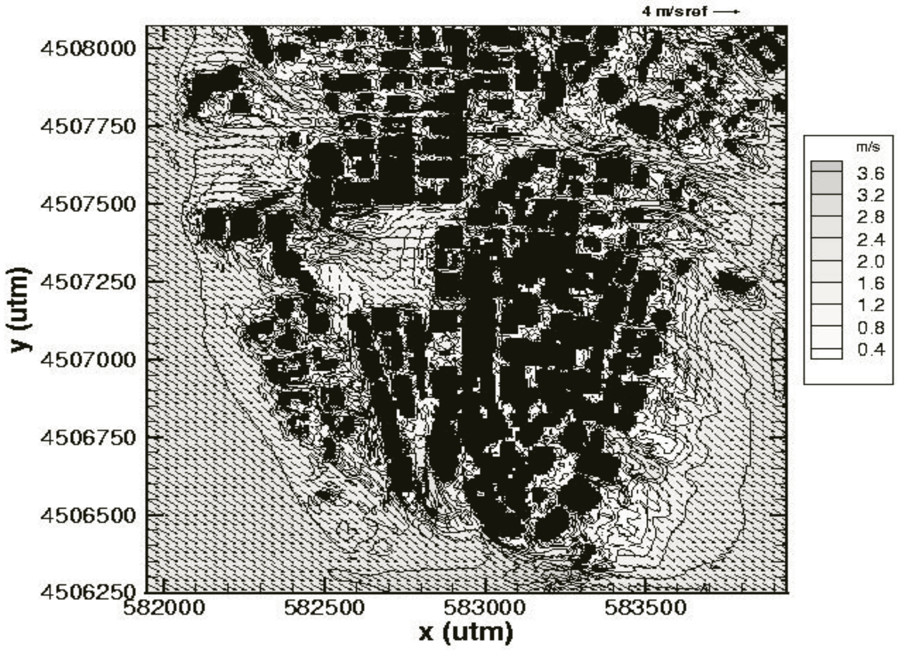

Figure 2. Wind field vectors and wind speed near pedestrian level. Ambient wind is from 300^{o}.

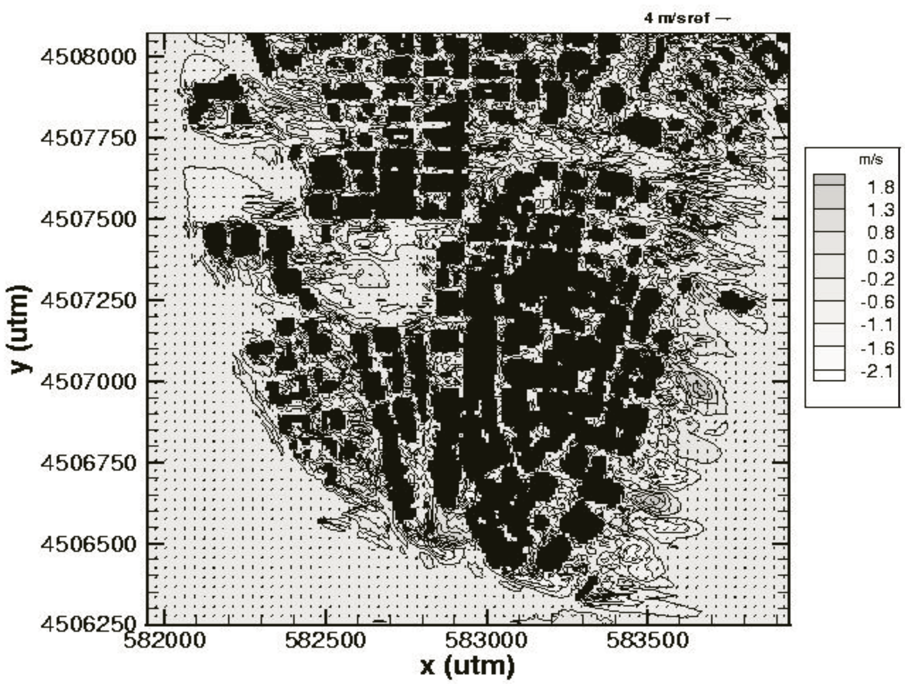

Figure 3. Difference fields for wind vectors and wind speed near pedestrian level. Wind direction difference=15^{o}.

street network alignment and surrounding terrain type must be considered in the construction of CFD generated wind field libraries. The next simulations that we will perform for this area will include a power-law inflow profile and higher grid resolution in order to capture all streets in the domain.

6. REFERENCES

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