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Large-eddy simulation of urban dispersion during the URBAN2000 field program IOP-10, 25-26 October 2000

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1. Introduction

In October 2000, the US Department of Energy, along with NOAA and several other government labs and universities, conducted the Vertical Transport and Mixing Experiment (VTMX) and URBAN2000 field programs in Salt Lake City, Utah (Alwine et al., 2002). The VTMX program focused on the basin-scale flow regime, where the URBAN2000 component focused on transport and dispersion in the downtown Salt Lake City area. In this paper, we will focus on a specific Intensive Operations Period, IOP-10, which occurred on October 25-26, 2000.

IOP-10 was chosen because the winds in the downtown area were fairly weak and variable early in the experiment, and became more windy in the later part of the IOP. The local conditions were influenced by a shortwave ridge, and were cloudy, with a weak and very shallow surface inversion, and light mean southerly flow over the area. An inert tracer gas, SF6, was released downtown Salt Lake City for a duration of one hour at three separate times on 26 October 2000, 01:00-02:00, 03:00-04:00, and 05:00-06:00 MDT. This paper will focus on the first release time, from 01:00-02:00 MDT.

2. Discussion

The large-eddy simulation (LES) code used for this work is HIGRAD (Smith et al., 2001; Reisner et al., 2001; Smith et al., 2002). HIGRAD uses state-of-the-art numerical techniques to accurately predict the evolution of atmospheric phenomena from micro-scale to meso-scale flows. HIGRAD uses a grid system that incorporates the features and advantages of both a generalized coordinate system, and a terrain following coordinate system. The model is second-order accurate in space and time, and uses either a Smagorinsky type, or one-equation turbulent kinetic energy based sub-grid closure. Advection of model variables is done using a non-oscillatory forward-in-time advection scheme (MPDATA) that can accurately model regions of strong shear. The model can be run in an anelastic mode, or, alternatively, it can solve the fully compressible Navier-Stokes equations. HIGRAD is designed to run on computers using massively parallel architecture.

The model domain encompasses a 2×2×2 km region in downtown Salt Lake City, with the SF6 source location near the southeast corner of the domain. The buildings are explicitly resolved and were derived from a geographic information systems (GIS) database. The horizontal resolution was 10m in both east-west and north-south directions, and variable vertical resolution, the highest resolution near the surface with a ΔZ=2.5m, and lowest resolution near the top of the domain with a ΔZ=50m, 1.72 million grid points. The wind fields were initialized to 0.5 m/s from 135^o (southeasterly flow), with neutral stratification. This is an idealized case, representing the conditions near the SF6 release location.

The simulation was run for approximately 1 simulation hour before releasing a massless tracer. The results presented are shown near the end of the 1 hour release. Figure 2 shows the concentration near the release point, at the second vertical grid level, z=2.5m, with velocity vectors superimposed. Near the release point, the flow is quite complicated due to the presence of the building wakes and channeling. The bulk of the tracer is advected to the northwest, but a also goes to the east and northeast.

Figure 1 shows an isosurface of concentration as the plume is channeled through the city. The background depicts the ground level concentration and the velocity vectors near the surface. The plume transport is mostly toward the northwest, but the urban street canyon effects channel large

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portions of the plume down the narrow corridors between buildings. One may also see evidence of lofting that occurs near tall buildings, where the tracer near the ground is caught up in an updraft induced by the building. Though difficult to see in this figure, this occurs quite frequently in the simulation.

3. Conclusion

Some preliminary simulation results have been shown for an idealized representation of the URBAN2000 IOP-10. A more realistic inflow velocity profile will be used in subsequent simulations to more accurately reflect the conditions. These results will be presented orally during the conference, and a more detailed quantitative comparison of the simulation to measured SF6 concentrations will be shown.

Acknowledgement This work is sponsored by the US Department of Energy, Chemical and Biological Weapon National Security Program. Supercomputers and time were made available by the US DOE-Advanced Strategic Computing Initiative (ASCI) project.

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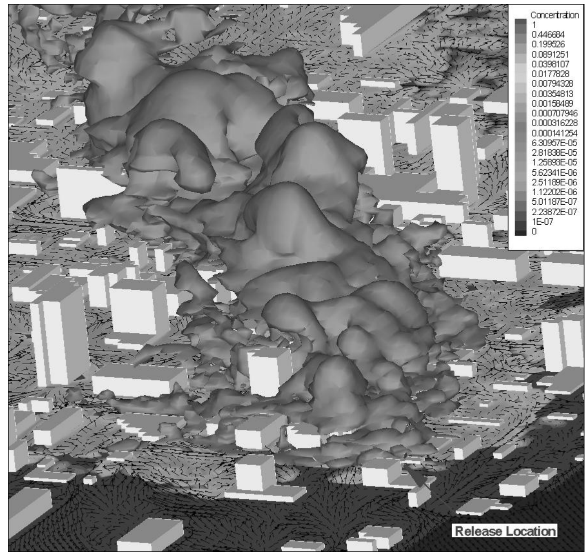

Figure 1: Simulated SF6 plume over downtown Salt Lake City, Utah.

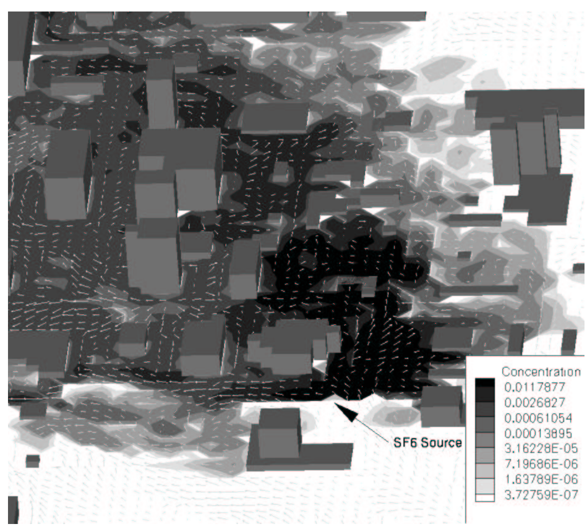

Figure 2: Wind and concentration fields at a height of 2.5m, near the source release point.