EFFECTS OF METEOROLOGICAL DATA THRESHOLDING ON THE QUALITY OF URBAN HPAC PREDICTIONS OF THE JOINT URBAN 2003 FIELD TRIAL OBSERVATIONS

N. Platt, S. Warner, J. T. Urban and J. F. Heagy
Institute for Defense Analyses, 4850 Mark Center Drive, Alexandria, VA 22311-1882, USA

INTRODUCTION

The potential effects of the atmospheric release of hazardous materials continue to be of concern to the nation – a concern especially acute in more densely populated urban areas. Estimates of the effects of hazardous releases within an urban environment on the underlying population are required to aid planning, emergency response, and recovery efforts. These estimates require accurate knowledge of the concentrations of dispersed material in time and space. Especially desired are estimates of where and when relatively low-level human effects thresholds are exceeded. A few recent field experiments have included the release of environmentally safe, inert, tracer gases in urban environments. For example, tracer gases were released in Salt Lake City, UT, in 2000 (Allwine et al., 2002) and during the Mock Urban Setting Test (MUST) at Dugway Proving Ground (Biltoft, 2002) and these experiments have been used to evaluate transport and dispersion models (Warner et al., 2004a, 2006). Under the joint sponsorship of the U. S. Department of Defense (Defence Threat Reduction Agency - DTRA) and U. S. Department of Homeland Security, a series of tracer gas releases were carried out in Oklahoma City starting on 28 June and ending on 31 July 2003 (Allwine et al., 2004). This field experiment, referred to as “Joint Urban 2003” (JU03), included ten intensive operating periods (IOPs), in which the tracer gas sulfur hexafluoride (SF_6) was released in downtown Oklahoma City. In total, twenty-nine 30-minute continuous SF_6 releases were accomplished with 2 hours of sampler monitoring following the start of each release. A separate presentation in this proceeding summarizes the general conclusions that we obtained evaluating Urban HPAC with the JU03 field trials (Urban et al., 2007). Additional information is available in Warner et al., 2007.

Intuitively, to obtain a better hazard prediction, one would like to measure the critical meteorological parameters as close as possible to the release location, and as often as possible. In terms of urban releases, this leads to the suggestion of using wind measurements at the altitudes that could be inside the “urban canopy.” These might include rooftop measurements, as was the case with the rooftop measurements associated with the relatively tall Latter Day Saints (LDS) building during the Salt Lake City field trials (Warner et al., 2004a), or the Botanical Gardens mini-SODAR used during the JU03 field trials. In past studies, we obtained somewhat contradictory results. Predictions based on the rooftop LDS measurements during the Urban 2000 field trials performed “worse” in terms of predicted potential hazard – and the most likely reason for this was that there were too many (non-representative) fluctuations in the wind directions. Meanwhile, predictions based on close-in SONICs measurements obtained at 16 meters above ground directly above the container array during the scaled MUST field experiment performed best (Warner et al., 2006) – it was postulated that in this case, the wind measurements at 16 meters (~ six times higher than the height of the containers) most likely sampled the relatively unperturbed flow and were hence more representative in terms of the input required for Urban HPAC. Of course, in the case of SODAR measurements taken within an urban area, low altitude measurements can be affected by obstacles with the urban canopy, while the upper altitude observations presumably measure the relatively unperturbed winds. How the use of these JU03 SODAR measurements affects the quality of urban HPAC predictions of the observed concentration observations is the subject of this paper.

BRIEF DESCRIPTION OF JU03 VERTICAL PROFILE METEOROLOGY

A large amount and variety of vertical wind profile meteorological measurements were made in the vicinity of Oklahoma City during the JU03 field experiment. Figure 1 shows the locations of some of these measurements.

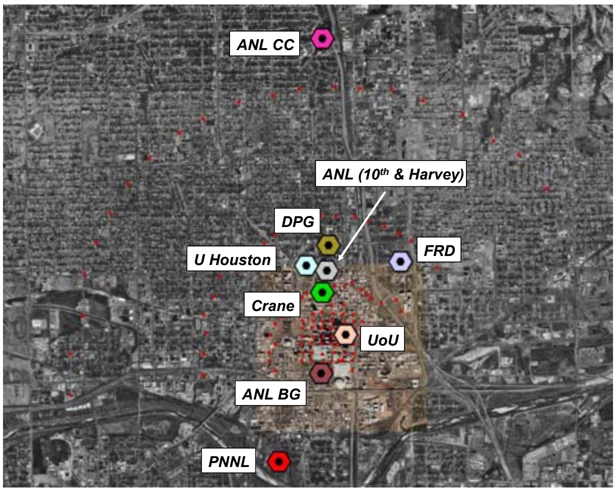

Fig. 1. Locations of some vertical wind profile measurements during JU03. Red circles correspond to surface sampler locations.

When enough vertical wind measurement data were available, Urban HPAC predictions were run for all individual vertical wind profiles obtained with the instruments shown in Figure 1. To study the effects of low altitude meteorological observations within the urban canopy on urban HPAC prediction quality, we varied the “cut-off” altitude below which wind measurements were ignored. For brevity, we denote the studied meteorological inputs as follows: (1) upwind of the Oklahoma City downtown area, wind measurements obtained from the PNNL SODAR (*PNNL*), (2) downtown wind measurements, obtained from the Botanical Gardens mini-SODAR (*ANL BG*) and (3) downwind of the downtown area, wind measurements obtained from the Christian Church mini-SODAR (*ANL CC*).

BRIEF DESCRIPTION OF URBAN HPAC MODES USED FOR COMPARISONS

HPAC (DTRA, 2001) is composed of a suite of software modules that can generate source terms for hazardous releases, retrieve and prepare meteorological information for use in a prediction, model the transport and dispersion of the hazardous release over time, and plot and report the results of these calculations. By using HPAC to provide predictions in an urban environment, one can conveniently capture some of the effects of the urban canopy on transport and dispersion by setting the surface type to “urban.” In addition to this baseline Urban HPAC predictive capability described above, we also used an urban dispersion model (UDM) component of Urban HPAC developed by the U. K.’s Defense Science and Technology Laboratory developed (Hall et al., 2002). In order to use UDM, Urban HPAC provides a building database with the locations, planar geometries, and heights of buildings to support the calculation of flows in the urban regime. We denote Urban HPAC predictions based on urban canopy parameterization as UC, and Urban HPAC predictions based on UDM as DM. The MC-SCIPUFF mass consistent module resident within Urban HPAC was used to create gridded wind fields from the (mini-) SODAR vertical profile data used in this study. Table 1 lists naming convention for Urban HPAC predictions that is used here.

Table 1. Urban HPAC predictions naming convention

Name	Cut-Off Altitude, meters	Sodar
SBG	none	*ANL BG*
SB1	30	*ANL BG*
SB2	50	*ANL BG*
SB3	70	*ANL BG*
PNS	none	*PNNL*
PS2	50	*PNNL*
PS3	70	*PNNL*
PS4	100	*PNNL*
PS5	150	*PNNL*
PS6	250	*PNNL*
PS7	350	*PNNL*
ACS	none	*ANL CC*
AS1	30	*ANL CC*
AS2	50	*ANL CC*
AS3	70	*ANL CC*
AS4	100	*ANL CC*

For this analysis, predictions and observations paired in space and time – referred to "point-to-point" – were compared. For each release, predictions and observations at four 30-minute average concentrations for each release were compared. We used a user-oriented measure of effectiveness (MOE) (Warner et al., 2004b) that allowed for assessments of the ability of the model to predict either the "hazardous" region (i.e., region above a concentration threshold of interest) or total average concentrations.

SUMMARY OF RESULTS

Figures 2 and 3 show MOE plots comparing urban HPAC predictions based on altitude "thresholding" of the *PNNL*, *ANL BG*, and *ANL CC* (mini-)SODARs using HPAC's baseline urban mode UC. In the figure 2, the MOE plots depict resampled two-dimensional (2D) MOE values obtained for the 12 nighttime releases, while in the figure 3, the MOE plots depict resampled 2D MOE values obtained for the 17 daytime releases. The top MOE values in each figure are based on a 250 parts per trillion (ppt) threshold and are used to assess model performance with respect to predicting the hazard area (in this case above a threshold of 250 ppt), while the bottom MOE values are based on 30-minute average concentrations and are used to assess model performance with respect to predicting the dosage that could have been obtained at the samplers (at least in 30-minutes). We note that for the daytime releases there is little effect on the MOE values as a function of withholding the low-altitude (mini-) SODAR measurements for any of the depicted locations. On the other hand, during the nighttime releases, there is a significant movement of the MOE "clouds" (i.e., approximate [resampled] 0.99 confidence region cluster) as the altitude below which the (mini-) SODAR measurements are withheld is increased. This is true for both the threshold-based and average concentration MOE values. The worst performance (i.e., when the MOE confidence region is closest to (0,0)) is for the predictions based on the full set of (mini-) SODAR wind measurements. As the altitude below which the wind measurements are withheld is increased, the MOE resampled clusters move on a "curve" that leads to improved performance for both *ANL BG* and *ANL CC* mini-SODARs (MOE clouds are closer to (1,1) and towards the diagonal). For the *PNNL* SODAR MOE resampled clusters, the initial improvement is followed by a degradation in MOE value (further from (1,1) and from the diagonal) as the altitude below which the measurements are withheld is increased past approximately 70-100 meters. We note that both *ANL BG* and *ANL CC* used mini-SODARs, and as such, the associated wind measurements did not extend as high as the *PNNL* SODAR. Otherwise, we expect to find that the MOE values based on the *ANL BG* and *ANL CC* "low altitude meteorological thresholding" would show similar degradation as a function of the cut-off altitude as the *PNNL* SODAR. Analogous findings were obtained using the UDM module within Urban HPAC.

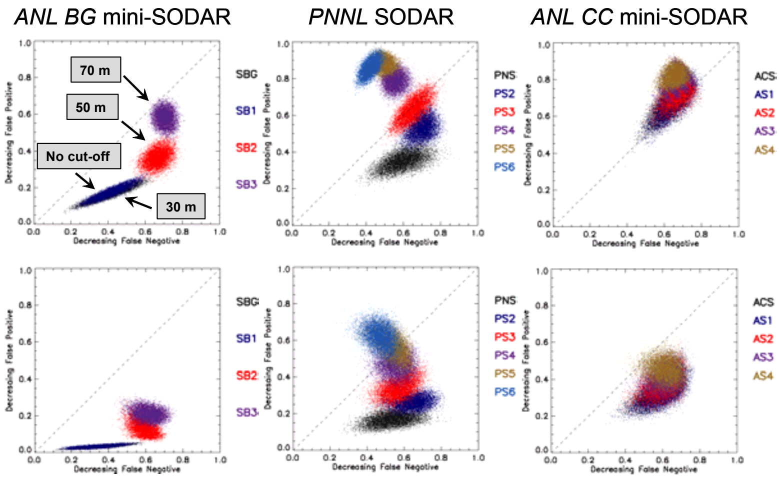

Fig.2 ANL BG, PNNL *and* ANL CC *(mini-) SODARs resampled MOE values as a function of cutoff altitude for 12 nighttime UC predictions of JU03.*

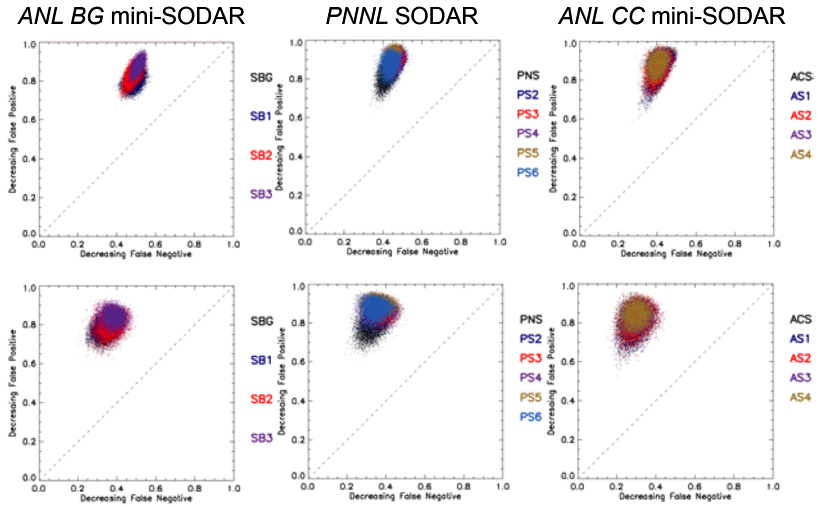

Fig.3 ANL BG, PNNL *and* ANL CC *(mini-) SODARs resampled MOE values as function of cutoff altitude for 17 daytime UC predictions of JU03.*

CONCLUSIONS

An important conclusion of this study is that at night, the (mini-) SODAR measurements below approximately 70-100 meters should not be used as input when creating urban HPAC predictions for JU03. During the daytime releases, all available vertical wind measurements from the (mini-) SODARs could be used to obtain reasonable urban HPAC predictions for JU03. This is consistent for all (mini-) SODARs that had enough altitude data collected during JU03. We suspect that this is result is caused by changes in the height of the boundary layer above Oklahoma City during the night similar to stability category changes between daytime and nighttime for non-urban terrain. Figures 4 depict wind vector profiles at the *ANL BG* and *PNLL* (mini-) SODARs as a function of time (at night) and altitude. In both cases, one can see different wind speeds and/or directions at low altitudes from higher altitudes. Recently, we obtained two additional urban modelling systems: MESO/RUSTIC developed by ITT and QUIC-URB/QUIC-PLUME developed by Los Alamos National Laboratory. We are planning to repeat the low-altitude (mini-) SODAR data withholding analysis discussed here with either or both of these systems to see if the conclusions obtained using urban HPAC can be extended to these modelling systems as well.

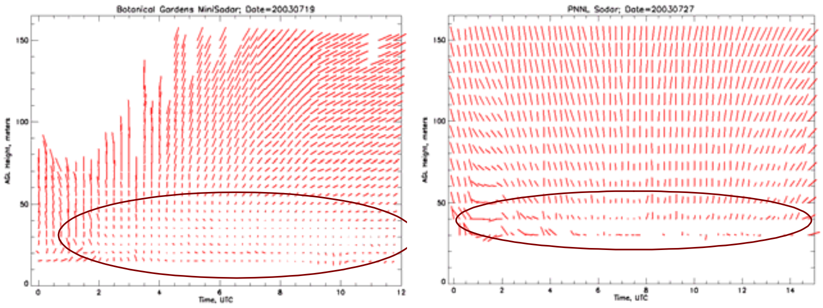

Fig. 4. ANL BG *(left, July 19, 2003) and* PNNL *(right, July 27, 2003) (mini-) SODARs wind vector profiles as a function of time (at night) and altitude.*

Acknowledgments: This effort was supported by the Defense Threat Reduction Agency with Dr. John Hannan as the project monitor and the Central Research Program of the Institute for Defense Analyses. The views expressed in this paper are solely those of the authors.

REFERENCES

Allwine, K. J., J. H. Shinn, G. E. Streit, K. L. Clawson, and M. Brown, 2002: Overview of URBAN 2000, A multiscale field study of dispersion through an urban environment. Bull. Amer. Meteor. Soc., 83, 521-536.

Allwine, K. J., M. J. Leach, L. W. Stockham, J. S. Shinn, R. P. Hosker, J. F. Bowers, and J. C. Pace, 2004: Overview of joint urban 2003—An atmospheric dispersion study in Oklahoma City. Preprints, Symp. on Planning, Nowcasting and Forecasting in the Urban Zone, Seattle, WA, Amer. Meteor. Soc., CD-ROM, J7.1.

Biltoft, C. A., 2002: Customer report for Mock Urban Setting Test, DPG Document No. WDTC_FR-01-121, Meteorology and Obscurants Division, West Desert Test Center, U. S. Army Dugway Proving Ground, Dugway Utah, 84022-5000, 58 pp.

DTRA, 2001: The Hazard Prediction and Assessment Capability (HPAC) user's guide version 4.0.3. Prepared for the Defense Threat Reduction Agency by Science Applications International Corporation, Rep. HPAC-UGUIDE-02-U-RAC0, 602 pp.

Hall, D. J., A. M. Spanton, I. H. Griffiths, M. Hargrave, and S. Walker, 2002: The Urban Dispersion Model (UDM): Version 2.2. Defense Science and Technology Laboratory Tech. Doc. DSTL/TR04774, 106 pp.

Lim, D., D. S. Henn, and R. I. Sykes, 2003: UWM Version 0.1. Prepared for the Defense Threat Reduction Agency by Titan Research and Technology Division, Titan Corporation, Tech. Doc., 42 pp.

Urban, J. T., S. Warner, N. Platt, J. F. Heagy 2007: Assessment of HPAC Urban Modelling Capabilities using Joint Urban 2003 Field Trial Data. Paper in this proceeding

Warner, S., N. Platt, and J. F. Heagy, 2004a: Comparisons of transport and dispersion model predictions of the URBAN 2000 field experiment. J. Appl. Meteor., 43, 829-846.

Warner, S., N. Platt, and J. F. Heagy, 2004b: User-oriented two-dimensional measure of effectiveness for the evaluation of transport and dispersion models. J. Appl. Meteor., 43, 58-73.

Warner, S., N. Platt, and J. F. Heagy, 2006: Comparisons of transport and dispersion model predictions of the Mock Urban Setting Test field experiment. J. Appl. Meteor., 45, 1414-1428.

Warner, S., N. Platt, J. T. Urban and J. F. Heagy, 2007: Comparison of Transport and Dispersion Model Predictions of the Joint Urban 2003 Field Experiment. Institute for Defense Analyses Paper P-4195, 244 pp. [Available from Steve Warner, Institute for Defense Analyses, 4850 Mark Center Drive, Alexandria, VA 22311-1882.].