Comparison of ADMS and PRIME

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1. Introduction

In 1992, the Electric Power Research Institute (EPRI) decided to embark upon a program (project PRIME: Plume Rise Model Enhancements) to design a new downwash model to correct the deficiencies in the ISC model. David Apsley's first BUILD report was published in 1988. European work has almost been totally ignored in the PRIME study. The concepts used in ADMS BUILD were first described at EUROMECH 163 in 1982 (Hunt and Robins, 1982), and in further detail in Robins (1983). PRIME developers (and EPRI) obviously knew of ADMS through formal and informal links. That no mention of ADMS BUILD can be found in the (refereed) JAWMA paper describing PRIME is very surprising.

The main features of the two models are summarise in Section 2, the data used to examine performance in Section 3, and related discussion in Section 4. References are listed in Section 5 and ADMS publications in Section 6.

2. Flow field regimes and modelling

Feature	PRIME	ADMS
Applicability	• not stated • presumably as ISC3	• within defined building effects region
Building effects region	• not stated • presumably as ISC3	• Xupwind, Zmax, ±Ymax defined • no downstream limit
Building pre-processing	• EPA BPIP pre-processor	• equivalent single rectangular block, plus orientation
Upwind	• empirical velocity field • undisturbed flow dispersion	• undisturbed flow and dispersion • impact on front face • plume splitting
Around building and near-wake	• empirical streamline slopes, Snyder & Lawson, 1993, fitted to near-wake boundary shape • no effect of orientation stated • dZsl/dx decays as z^{-1} • dYsl/dx – not stated • linear spread if plume intercepts wake boundary	• streamline slopes fitted to near-wake boundary shape • slope a function of orientation • slope decrease linearly with height • dZsl/dx=0 at & above Zmax • dYsl/dx=0 everywhere • ambient spread laws
Near-wake	• elliptic in X-Z and X-Y	• elliptic in X-Z, parallel sided

boundary	• roof reattachment criterion for Xsep, Wilson, 1979 • $Z_R$max, Snyder & Lawson, 1993 • L_R from Fackrell, 1984	• roof reattachment criterion for Xsep, based on data of Fackrell, 1984 • $Z_R$max • L_R from Fackrell, 1984
Near-wake (internal source)	• modified Gaussian model for concentrations • $d\sigma_{Y,Z}/dx \approx 0.34, 0.45$ • $C(x,0,0) \approx 1/H_R W'_R$	• box model for concentrations, C_R=constant in the near-wake • T_R from Fackrell, 1984
Near-wake (external source)	• Q_R based on flux crossing boundary • C_R calculated from modified Gaussian near-wake model	• C_R from mean of concentrations over boundary (Puttock & Hunt, 1979) • Q_R and fraction entrained from near-wake box model
Main wake (velocity field)	• empirical streamline slopes • wake dimensions, Wilson 1979; Snyder & Lawson, 1993 • turbulence field and velocity deficit from free-wake theory, Weil, 1996 • dZsl/dx decays as x^{-1}, z^{-1} • dYsl/dx not stated	• wake dimensions, velocity and turbulence fields from wall-wake theory, Counihan et al, 1974 • dYsl/dx, dZsl/dx from velocity field • dZsl/dx=0, Z>Zmax • dYsl/dx=0, |Y|>Ymax
Main wake (concentration field)	• two zone dispersion model, uses wake and external spreading rates, according to Yp, Zp? • wake region eddy-diffusivity model for lateral and vertical spread • elevated and ground based plume components	• six zone dispersion model, uses wake and external spreading rates, according to Yp, Zp • wake region eddy-diffusivity model for lateral and vertical spread • elevated and ground based plume components
Near-wake, main-wake boundary	• patched over a transition zone at $X_R(1\pm0.15)$	• discontinuous
Far field	• virtual source model for concentrations once wake decayed, or X>15Hb	• model applied at all distances downwind
Plume lift-off from near-wake	• plume rise calculation with U≈Uh/3 in near-wake	• criteria related to buoyancy and momentum length scales • plume rise calculation if criteria met
Plume trajectory	• integral model • entrainment theory • references Zhang & Ghoniem, 1993, (a model using Lagrangian vortex methods)	• integral model based on development of Ooms, 1972 • entrainment theory • plume rise corrected for mean streamline displacements

3. Data used and reported for testing performance

Data source	Type	PRIME	ADMS
Barret, CF, Hall, DJ and Simmonds, AC, 1978. Dispersion from chimneys downwind of cubical buildings - a wind tunnel study. Proc. NATO/CCMS 9th Int. Mtg. on Air Pollution Modelling and its Applications, Toronto, Canada, August 28-31, 1978.	Wind tunnel Neutral bl Passive plume Maximum glc	n/a	all cases
Cowan, IR, 1996. A comparison of wind tunnel experiments and computational simulations of dispersion in the environs of buildings. Proc. 4th Workshop on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes, Ostend, Belgium, 6-9 May, 1996.	Wind tunnel & CFD Neutral bl Passive plume C(x,y, z) Short range	n/a	1 case
Engineering Science, 1980. Field evaluation of atmospheric dispersion models for natural gas compression studies. Report No. PR-133 for American Gas Association.	Field Buoyant plume glc, 63 hours Short range	max glcs	n/a
Foster, PM & Robins, AG, 1985. The effects of buildings on low-level atmospheric discharges, CEC Report, EU99980 EN, 1985.	Field & w/t Near-neutral bl Passive plume C(x,y, z) Short range	n/a	all cases
Guenther, A, Lamb, B and Allwine, E, 1989. Building wake dispersion at an arctic industrial site: field tracer observations and plume model evaluations. Atmos. Environ., 24A, 2329-2347.	Field Strong winds Gas turbine glc, 10 expts 20-3400m	all cases (also used in model development)	n/a
Hall, DJ, Kukadia, V, Walker, S & Marsland, G.W., 1995, Plume dispersion from chemical warehouse fires, BRE Client Report CR 56/95.	Wind tunnel Neutral bl Buoyant plume C(x,y,0) Medium range	n/a	all cases
Huber, AH & Snyder, WH, 1982. Wind tunnel investigation of the effects of a rectangular-shaped building on dispersion of effluents from short adjacent stacks, Atmos. Environ, Vol. 16, p. 2837 – 2848.	Wind tunnel Neutral bl Passive plume C(x,0,0) Short range	n/a	all cases
Koga, DJ and Way, JL, 1979. Effects of stack height and position on the dispersion of pollutants in building wakes. Illinois Inst. of Technology, Fluids & Heat Transfer Report R79-2.	Wind tunnel Neutral bl Passive plume C(x,y,0) Short range	n/a	qualitative comparisons & sensitivity tests
Macdonald, HF, Foster, PM, Robins, AG &	Field & w/t	n/a	all cases

Thompson, IMG, 1988. Improved estimates of external gamma dose rates in the environs of Hinkley Point Power Station, CEGB Report, RD/B/6027/R88, 1988.	Near-neutral bl Buoyant plume C(x,y, z) Medium range		
Melbourne, WH & Taylor, AJ, 1994. Wind tunnel studies of plume dispersion from the Lee Power Plant Power Station. EPRI Report TR 135274, Palo Alto, CA	Wind tunnel Neutral bl Buoyant plume C(x,y, z) Short range	all cases	n/a
Robins, AG & Castro, IP, 1977. A wind tunnel study of plume dispersion in the vicinity of a surface mounted cube. Atmos. Environ., Vol. 11, p 291 – 311.	Wind tunnel Neutral bl Passive & with momentum C(x,y,z) Medium range	n/a	max glcs, stack emissions
Robins, AG, Hayden, P & Teasdale, I, 1998. Dispersion from elevated sources above obstacle arrays - modelling requirements. Int. J. Environment and Pollution, in press.	Wind tunnel Neutral bl Passive plume C(x,y,z) Medium range	n/a	qualitative comparisons and sensitivity tests
Schulman, LL and Hanna, SR, 1986. Evaluation of downwash modifications to the industrial source complex model. J. Air Poll. Control Assoc., 36, 258-264.	Field Whole year Power plant 4 sites within 1km	10 highest glc	n/a
Snyder, WH, 1992. Wind tunnel simulation of building downwash from electric power generating stations; Part I: Boundary layer and concentration measurements. USEPA, Res. Triangle Park.	Wind tunnel Neutral bl Buoyant plume C(x,y, 0) Short range	5 cases (also used in model development)	n/a
Start, GE, Hakari, NF, Sagendorf, JF, Cate, JH & Dickson, CR, 1981. EOCR building wake effects on atmospheric diffusion. NUREG/CR1395, NOOA, Idaho Falls, ID	Field Passive plume glc, 22 hours C(x,y,0) 37-1600m	max glcs	n/a
Thomson, RS, 1993. Building amplification factors for sources near buildings: a wind tunnel study. Atmos. Environ., 27A, 2313-2325.	Wind tunnel Neutral bl Passive plume C(x,0, 0) Short range	1 case	n/a
Thompson, RS & Lombardi, DJ, 1977. Dispersion from roof-top emissions from isolated buildings – a wind tunnel study, US EPA Report, EPA-600/4-77-006.	Wind tunnel Neutral bl Passive plume C(x,y, z) Short range	n/a	all cases

5. References:

5.1 For PRIME:

Paine, RJ & Lew, F, 1997. Results of the independent evaluation of ISCST3 and ISC-PRIME. EPRI Final Report TR-2460026, EPRI, Palo Alto, CA, November 1997

Paine, RJ & Lew, F, 1998. Project PRIME: evaluation of building downwash models using field and wind tunnel data. Paper No. 4B2, 10th Joint Conf. on the Applications of Air Pollution Meteorology, Phoenix, AZ, 1998

Schulman, L L , Stirmaitis, D G & Scire, J S, 2000. Development and evaluation of the PRIME plume rise and building downwash model. J. Air & Waste Management Assoc., 50, 378-390, March, 2000

Weil, JC, 1996. A new dispersion model for stack sources in building wakes. Proc. 9th Joint Conf. on Applications of Air Pollution Meteorology with AWMA, American Met. Soc., Boston, MA, 1996, 333-337.

5.2 For ADMS:

Counihan, J, Hunt, JCR & Jackson, PS, 1974. Wakes behind two-dimensional surface obstacles in turbulent boundary layers, J. Fluid Mech., Vol. 64, p. 529 – 563, 1974.

Fackrell, JE, 1984. Parameters characterising dispersion in the near-wakes of buildings, J. Wind Eng. and Industrial Aero., Vol. 16, p. 97 – 118, 1984.

Puttock, JS & Hunt, JCR,1979. Turbulent diffusion from sources near obstacles with separated wakes, Atmos. Environ., Vol. 13, p. 1 – 13, 1979.

Robins, AG, McHugh, CA & Carruthers, DJ, 1997. Testing and evaluating the ADMS building effects module. Int. J. Environment and Pollution, 8, 3-6, 708-717

Robins, AG and McHugh, C, 1999. Development and Evaluation of the ADMS Building Effects Module. Proc 6th International Conf. on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes, Rouen, France, 11-14 October, 1999

6. ADMS Publications

Robins A G, Hayden, P and Teasdale, I, 2000. Dispersion from elevated sources above obstacle arrays - modelling requirements. Int. J. Environment and Pollution, 1, 1-4, in press

Robins, A G and McHugh, C, 1999. Development and Evaluation of the ADMS Building Effects Module. Proc 6th International Conf. on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes, Rouen, France, 11-14 October, 1999

Robins A G, Hayden, P and Teasdale, I, 1998. Dispersion from elevated sources above obstacle arrays - modelling requirements. 5th International Conf. on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes, Rhodes, Greece, 18-21 May, 1998

CERC, 1998. Technical specification of ADMS 2.2 (18/2/98), CERC, Cambridge.

Robins, A G, McHugh, C A & Carruthers, D J, 1997. Testing and evaluating the ADMS building effects module. Int. J. Environment and Pollution, 8, 3-6, 708-717

Robins, A G, McHugh, C A & Carruthers, D J, 1996. Testing and evaluating the ADMS building effects module. Proc. 4th Workshop on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes, Oostende, 6-9 May, 1996.

CERC, 1995. Technical specification of ADMS 1.5 (3/7/95), CERC, Cambridge.

DJ Carruthers, RJ Holroyd, JCR Hunt, WS Weng, AG Robins, DD Apsley, DJ Thomson, FB Smith, 1994. UK-ADMS - a new approach to modelling dispersion in the earth's atmospheric boundary layer. J Wind Eng Ind Aerodyn, 52, 139-153

Carruthers, DJ, McHugh, CA, Robins, AG, Thomson, DJ, Davies, B, Montgomery, M, 1993. UK Atmospheric Dispersion Modelling System: Validation Studies Proc. NATO/CCMS 20th Int. Conf. on Air Pollution Modelling and its Applications, Valencia, Spain, 1993

Carruthers, DJ, Holroyd, RJ, Hunt, JCR, Weng, WS, Robins, AG, Apsley, DD, Thomson, DJ, Smith, FB, 1992. UK-ADMS - a new approach to modelling dispersion in the Earth's atmospheric boundary layer. Proc . Inaugural Conf. Wind Eng. Soc., Cambridge, 28-30 September, 1992

Carruthers, DJ, Holroyd, RJ, Hunt, JCR, Weng, WS, Apsley, DD, Smith, FB, Thomson, DJ, Hudson, B, 1991. UK atmospheric dispersion modelling system Proc. NATO/CCMS 19th Int. Conf. on Air Pollution Modelling and its Applications, Crete, Greece, 1991

Hunt, JCR, Holroyd, RJ, Carruthers, DJ, Apsley, DD, Smith, FB, Thomson, DJ, 1990. Developments in modelling air pollution for regulatory uses Proc. NATO/CCMS 18th Int. Conf. on Air Pollution Modelling and its Applications, Vancouver, Canada, 1990

Apsley, DD, 1990. Modelling of building effects in UK ADMS 1.0, ADMS Paper, P16/01A/90 (12/3/1990), CERC, Cambridge

Apsley, DD, 1988. A model for dispersion in the wake of large buildings. CEGC Report, RD/L/3359/R88, CEGB

Robins, AG, 1983. Recent advances in the modelling of dispersion near buildings. Proc. 'Heat and Fluid Flow in Nuclear and Process Plant Safety', I. Mech Engrs., 1983.

Hunt, JCR and Robins, AG, 1982. A model for assessing dispersion of plumes from sources in the vicinity of cuboid shaped buildings. Proceedings EUROMECH 162 (Ed: AR Janeiro Borges), 110-116, New University of Lisbon, 1982

Carruthers D.J., Mckeown A.M., Hall D.J. & Porter S. (1999), Validation of ADMS against wind tunnel data of dispersion from chemical warehouse fires, Atmos. Environ., Vol. 33, p. 1937 – 1954, 1999.

Counihan J., Hunt J.C.R. & Jackson P.S. (1974), Wakes behind two-dimensional surface obstacles in turbulent boundary layers, J. Fluid Mech., Vol. 64, p. 529 – 563, 1974.

Fackrell J.E.. (1984), Parameters characterising dispersion in the near-wakes of buildings, J. Wind Eng. and Industrial Aero., Vol. 16, p. 97 – 118, 1984.

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Robins A.G., Speirs L.J. & Roberts P.E. (1999), The structure of wakes from three-dimensional porous obstacles in a deep, turbulent boundary layer. Wind Engineering into the 21st Century (Larsen, A, Larose, L and Livesey, F M, Eds), A A Balkema, Rotterdam, Vol. 3, p. 1717-1724, 1999.