Description of model ADMS-Urban

Basic information

Model name

ADMS-Urban

Full model name

Atmospheric Dispersion Modelling System (Urban)

Model version and status

Version 4 (February 2016)

Institutions

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URL

http://www.cerc.co.uk/

Technical support

help@cerc.co.uk

Level of knowledge needed to operate model

Intermediate

Remarks

Numerate graduate level. Training strongly recommended.

Intended field of application

Urban air quality assessment and forecasting taking into the full range of emission source types including: road traffic, industrial, commercial and domestic emissions. ADMS-Urban is used to assess compliance with the EU Air Quality Directive: compliance/assessment; planning and mitigation; source apportionment; public information and forecasting; It is used to model current and future scenarios on behalf of local government authorities and national government. It has/is also used for policy support for the UK Department of the Environment and in other EU countries e.g. assessment of exceeedence of UK National Air Quality Strategy objectives, EU air quality standards and proposed EU standards.

Model type and dimension

Advanced three dimensional quasi-Gaussian model nested within a trajectory model.

Model description summary

ADMS-Urban is a PC based air quality management system of dispersion in the atmosphere of passive, buoyant or slightly dense, continuous releases from single or multiple sources which may be point area or line (road) sources. The model uses an up to date parameterisation of the boundary layer structure based on the Monin-Obukhov length LMO, and the boundary layer height h. The model is a substantial development of the industrial source model ADMS 4 and has quite a different user community. Significant features beyond those in ADMS 4 include an emission inventory framework and allowance for a large number of different sources (up to 7500) in any model run.

The system has a number of distinct features which can be summarised as follows:
(i) concentration distributions are Gaussian in stable and neutral conditions, but the vertical distributions is non-Gaussian in convective conditions to take account of the skewed structure structure of the vertical component of the turbulence.
(ii) a meteorological pre-processor which calculates the required boundary layer parameters from a variety of input data: eg wind speed, day time cloud cover or wind speed, surface heat flux and boundary layer height. Meteorological data may be raw, hourly averaged or statistically analysed data.
(iii) Calculation of averages of mean concentration and deposition and mean concentration percentiles for averaging time from 10 minutes to a year.
(iv) a range of modules allow for the effects of plume rise, complex terrain, street canyons, noise barriers and buildings
(v) explicit NOx chemistry modelling (NO, NO2, O3, VOC) and sulphate chemistry including a grid-based trajectory model to account for the chemical reactions between the background data site and the domain of interest. Changes in primary NO2 and changes in background ozone can be modelled.
(vi) full integration with a Geographical Information System (ArcGIS and MapInfo) allowing easy emission set-up , output presentation and analysis.
(vii) links to pollution concentration monitoring data for display of results against monitored data and meteorological forecasts for air quality forecasting.

Model limitations/approximations

Decreasing accuracy with calm wind conditions. Rapidly changing weather conditions (less han one hour).

Resolution

Temporal resolution

Model is time independent so there are no time steps.

Horizontal resolution

No limits to spatial resolution.

Vertical resolution

No limits to spatial resolution.

Schemes

Advection & Convection

Advected at wind speed at mean plume height.

Turbulence

Turbulence profiles based on surface similarity and boundary layer scaling. Measured vertical profiles of turbulence can be utilized if available.

Deposition

Deposition and scavenging based on deposition velocity (species, particle size dependent) and washout coefficient.

Chemistry

Atmospheric chemistry based on Generic Reaction Scheme (NO, NO2, O3, VOC) and includes sulphate chemistry.

Solution technique

No numerical methods required except Runge Kutta for plume rise model and adaptive time stepping for chemistry.

Input

Availability and Validation of Input data

Met data

Met data can be obtained from national or international met services. Data will usually be hourly surface data comprising day, time, wind speed, wind direction, near surface temperature, precipitation, cloud cover or solar radiation as a minimum. The user enters the height at which the wind speed was measured. Vertical profile data may also be utilized.

Topographical data

Topographical data can be obtained from national providers or the US Geographical Survey. For input

to the model the user must construct a data set in a simple text format with the data (counter, X, Y, Z) .
Emissions
Input in units per second e.g. g/s for a point source or g/(km.s) for a road source.
Time varying emission factors can be provided, diurnal and monthly profiles or a time series with hourly values for one day.
Background concentration data
When used in short term forecasting mode forecasts of ambient background concentrations are usually obtained from meso-scale models.

Emissions

Input geometry and units per second emitted. Time varying emission factors can be provided: diurnal and monthly profiles.

Meteorology

Time series of up to 5 years can be used. Forecast meteorology is used when the model is used to produce short term forecasts of air quality.

Topography

Terrain height and/or surface roughness entered as a grid of values.

Initial conditions

The model does not incorporate initial and boundary conditions.

Boundary conditions

The model does not incorporate initial and boundary conditions except backgound pollutant concentrations.

Data assimilation options

Met data
Met data can be obtained from national or international met services. Data will usually be hourly surface data comprising day, time, wind speed, wind direction, near surface temperature, precipitation, cloud cover or solar radiation as a minimum. The user enters the height(s) at which the wind speed was measured.

Topographical data
Topographical data can be obtained from national providers or the US Geographical Survey. For input to the model the user must construct a data set in a simple text format with the data (counter, X, Y, Z).

Emissions
Input in units per second e.g. g/s for a point source or g/(km.s) for a road source.
Time varying emission factors can be provided, diurnal and monthly profiles or a time series with hourly values for one day.

Other input requirements

Output receptors, averaging times, percentiles.

Output quantities

Mean concentration of pollutants for averaging times ranging from 10 minutes to 1 year (or more). Percentiles of concentration where required. Dry and wet deposition. Output from meteorological pre-processor. Forecasts of air quality for tomorrow and the day after tomorrow.

User interface availability

Windows (XP, Vista, 7) user interface includes link to a Geographical Information System (ArcGIS, MapInfo), and emissions inventory databases including EMIT (Emissions Inventory ToolKit).

User community

Local government, universities, research institutes and on behalf of national government for air quality assessments of urban areas and investigation of current and predicted national air quality objectives.

Previous applications

1.

Application type

Regional

Application description

Reference:

CERC, Modelling Air Quality for London using ADMS-Urban (2003) TOPIC REPORT Prepared for DEFRA, National Assembly for Wales, The Scottish Executive, and the Department of the Environment, Northern Ireland

http://www.airquality.co.uk/archive/reports/cat12/final_doc.pdf

Short description:

The study modelled air quality in London in current and future years, incldiugn a *business as usual* scenario and alternative scenarios that may be employed to achieve the air quality objectives laid out in the UK air quality strategy. The modelled looked at the Greater London area using the Air Dispersion Modelling System ADMS-Urban to model several important pollutants: Nitrogen Dioxide (NO2); Oxides of Nitrogen (NOx); particles smaller than 10 microns diameter (PM10); and Ozone (O3).

Model performance:

Emissions of NOx and PM10 over the Greater London area have been modelled for the years 1999, 2004/05 and 2010 using meteorology from 1999 and worst case meteorology from 1996 (PM10) and 1997 (NO2). High resolution colour contour maps of ADMS-Urban calculated pollutant concentration were presented together with spot calculations at the automatic monitoring sites locations in London. For current years ADMS-Urban is good at predicting concentration at specified receptors, particularly annual average concentrations.

2.

Application type
Episodes

Application description
ADMS-Urban is used as part of the airTEXT forecasting and alerting system for London giving alerts if pollution is predicted to reach moderate or high levels. www.airTEXT.info The system has 5,000 people signed up to receive alerts. ADMS-Urban is or has also been used in forecasting and/or alerting systems for Beijing, Vienna, Budapest and in England: Liverpool, Wakefield, York, Avon.

Documentation status

Level 1. Documentation in English.
The User Guide (manual) including worked examples is supplied with the model.
A full Technical Specification describing model algorithms is available.

Validation and evaluation

Level 2.
[1] ADMS-Urban has been validated through its use in the many Review and Assessmnet studies that include a verification step.
[2] There has been extensive validation work for London:
http://www.airquality.co.uk/archive/reports/cat09/Validation&Sensitivity(22JAN03)10_TR-0191-h.pdf
http://www.airquality.co.uk/archive/reports/cat12/final_doc.pdf
[3] Validation using UK data for the M4 and M25 motorways.
http://www.cerc.co.uk/environmental-software/assets/data/doc_validation/CERC_ADMS-Urban_ADMS-Roads_validation_M4_M25.pdf
[4] validation using US data for the CALTRANS highway.
http://www.cerc.co.uk/environmental-software/assets/data/doc_validation/CERC_ADMS-Roads_validation_Caltrans99.pdf
[5] The underlying industrial models validated against data when available. Concentration predictions validated against all standard datasets (Prairie Grass, Kinciad, Indianapolis etc). Additional comparisons with LIDAR and wind tunnel data (see references). Comparison of concentrations with ambient air quality monitoring sites throughout the UK at cities including London, Cambridge, Glasgow, Belfast, Birmingham and Bristol.
Reference:
CERC, Validation and Sensitivity Study of ADMS-Urban for London. (2003) TOPIC REPORT Prepared for DEFRA, National Assembly for Wales, The Scottish Executive, and the Department of the Environment, Northern Ireland.

http://www.airquality.co.uk/archive/reports/cat09/Validation&Sensitivity(22JAN03)10_TR-0191-h.pdf
Short description:
ADMS-Urban was set up for use with the latest London Atmospheric Emissions Inventory for 1999 emissions and validated against continuous hourly measuremnts of NOX, NO2, O3 and PM10 from sites across London. In addition the sensitivity of predicted concentrations to model input data and set-up parameters has been investigated in detail.
Model performance:
The comparison confirmed the generally good performance of the model with the annual mean values of NO2 (overall fractional bias 0.02) and PM10 (overall fractional bias 0.048) being especially well predicted, although individual site locations are subject to greater errors e.g. the overall normalised mean square error for NO2 is 0.19.

Model intercomparison
Reference:
CERC, Comparison of ADMS-Urban, NETCEN and ERG Air Quality Predictions For London. (2003) TOPIC REPORT Prepared for DEFRA, National Assembly for Wales, The Scottish Executive, and the Department of the Environment, Northern Ireland.
http://www.airquality.co.uk/archive/reports/cat09/Comparison_17jun03_12_TR-0232.pdf
or CERC, 3 Kings Parade, Cambridge, CB2 1SJ
Short description:
Assessment of the performance of 3 local air quality models for calculating air quality across London at background and kerbside sites. The three models were used to predict concentrations of NOx, NO2 and PM10 for 1999, 2004 and 2005 at automatic monitoring sites, other receptor points and at each major road link. Calculated concentrations for 1999 are compared to monitoring data.
Model performance:
- NOx, NO2 at roadside sites
Comparisons made at monitoring sites show that the empirically based methodologies (NETCEN, ERG) tend to generate less NO2 for given NOx than ADMS-Urban.
- NOx, NO2 at background sites
These suggest good performance of ADMS-Urban and both the NETCEN and ERG empirically-based methodologies.
- PM10
Although ADMS-Urban, NETCEN and ERG show good general agreement with monitoring data, scatter plots of road contributions and percentages of road segments that exceed thresholds show significant differences between the models.

Frequently asked questions

- **Q:** How can calculated concentrations be compared to air quality limits and guidelines such as the UK National Air Quality Strategy?
  A: The user can compare calculated concentrations to the air quality limits and guidelines set out in the UK National Air Quality Strategy by selecting appropriate averaging times and percentile limits

and using a year of hourly sequential meteorological data. For example, the user can calculate the 99th percentile of 15 minute SO2 concentrations and the 8 hour running mean of CO simultaneously by entering 15 minutes as the SO2 averaging time and 8 hours at the CO averaging time and specifying the 99.9th percentile for SO2

- **Q:** Can an existing emissions inventory be used with ADMS-Urban?
  A: Yes. The ADMS-Urban interface links directly to Microsoft Access which can be used to query other databases provide they contain the appropriate data. Data can also be imported from ArcGIS and from EMIT (CERCs Emissions Inventory Toolkit).
- **Q:** Where can one obtain suitable meteorological data format use in ADMS-Urban calculations?
  A: CERC supply a number of sample meteorological files suitable for simple test calculations or to examine the effects of a range of individual stability categories on dispersion. If there is a Met Station on site, the data collected from it can normally be made into a format suitable for use in ADMS-Urban. Otherwise there is a utility to convert data supplied by the National Climate and Data Center in the US (check format first) and the UK Meteorological Office supplies worldwide data in a suitable format for ADMS-Urban.

Portability and computer requirements

Portability
Easily installed on PCs under Windows XP, Vista or 7.

CPU time
Seconds for one line of met data. Overnight for specified receptor output. Several days for contour plotting output.

Storage
Typically 10GB

Availability

Commercially available. Contact enquiries@cerc.co.uk

Summary description of model ADMS-Urban

Policy issue

- Ozone depletion
- Tropospheric ozone
- Air toxics
- Urban air quality
- Industrial pollutants
- Chemical emergencies

Application type

- Air quality assessment
- Regulatory purposes and compliance

- Policy support
- Public information
- Scientific research

Model output

- Concentrations
- Deposition fluxes
- Source-receptor relationships
- Exposure

Type of air pollution source

- Emissions from the stack of a plant (point source)
- Traffic emissions (line source)
- Area - volume source
- Multiple source
- Emission inventory database (gridded data)

Release type

- Continuous release without interruption
- Release with interruption (intermitted)
- Unexpected release (accidental)

Spatial scale of model application

- Local (up to 30 km)
- Local-to-Regional (30-300 km)

Simulation character

- Statistical (analysis of long-term AQ indicators)
- Episodic (analysis of short-term AQ indicators)
- Real time (on-line analysis of AQ indicators during episodes)

Form of release

- Sulphur Dioxide (SO2)
- Carbon monoxide (CO)
- Nitrogen Oxides (NOx)
- Volatile Organic Compounds (VOCs)
- Ozone (O3)
- Benzene
- Ammonia (NH3)
- Lead (Pb)
- PM2.5 and PM10

- Total Suspended Particulates (TSP)
- Buoyant

Contaminant properties

- Non-reactive primary pollutants
- Chemically active
- Pollutants which take part in intermediate transfer processes (dissolution, absorption, gravitational setting, precipitation affect, deposition, decay etc.)

Type of model

- Plume-rise models
- Gaussian models
- Lagrangian models
- Chemical models

Duration of the simulation

- 10 minutes to 1 hour
- 1 to 24 hours
- More than 24 hours

Computer Platform

- PC

References about model development (up to 5)

- D.J. Carruthers, H.A. Edmunds. C.A. McHugh and R.J. Singles (1998) Development of ADMS-Urban and comparison with data for urban areas in the UK. Proc. of Air Pollution Modelling and its Application XII. To be published by Pleunm Press.
- CERC (2001), Validation of ADMS-Urban and ADMS-Roads against M4 and M25 Motorway Data, www.cerc.co.uk/environmental-software/assets/data/doc_validation/CERC_ADMS-Urban_ADMS-Roads_validation_M4_M25.pdf or from CERC, 3 Kings Parade, Cambridge, CB2 1SJ, UK
- Carruthers D. J., McKeown A. M., Hall D. J. and Porter S. (1999) Validation of ADMS against Wind Tunnel Data of Dispersion from Chemical Warehouse Fires. Atmospheric Environment, Vol 33 pp. 1937-1953.

Other references

- Carruthers DJ, Dixon P, McHugh CA, Nixon SG, and Oates W. (1999) Determination of Compliance with UK and EU Air Quality Objectives From High Resolution Pollutant Concentration Maps Calculated Using ADMS-Urban. International Journal of Environment and Pollution (Volume 16, Nos. 1-6, 2001).
- C.A. McHugh, D.J. Carruthers and H.A. Edmunds (1997) ADMS-Urban: a model of traffic, domestic and industrial pollution. International Journal of Environment and Pollution, Volume 8, Nos. 3-6, pp. 666-674.

- Carruthers D. J., Edmunds H. A., Bennett M., Woods P. T., Milton M. J. T., Robinson R., Underwood B. Y. and Franklyn C. J. (1995). Validation of the UK-ADMS Dispersion Model and Assessment of its Performance Relative to R-91 and ISC using Archived LIDAR Data. Study commissioned by Her Majestys Inspectorate of Pollution (published by DoE). DoE/HMP/RR/95/022