Description of model ADMS 5

Basic information

Model name

ADMS 5

Full model name

Atmospheric Dispersion Modelling System 5

Model version and status

Version 5.1 (February 2016)

Institutions

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URL

www.cerc.co.uk/

Technical support

help@cerc.co.uk

Level of knowledge needed to operate model

Basic

Remarks

Numerate graduate level operator. Training advised.

Intended field of application

Air quality assessment worldwide; regulatory purposes and compliance for industrial sources (used by and on behalf of the Environment Agencies, for example in the UK and France, by industry and environmental consultancies); policy support (for example used in UK National Model for reporting to EU and for UK Air Quality Strategy for assessment of exceedence of EU and national air quality limits and standards); emergency responses (eg for chemical spills); scientific research; listed in the US EPA Appendix W list of alternative models.

Model type and dimension

Advanced three dimensional quasi-Gaussian model.

Model description summary

ADMS 5 is a PC based model of dispersion in the atmospheric of passive, buoyant or slightly dense, continuous or finite duration releases from single or multiple sources which may be point, area or line 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 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 distribution is non-Gaussian in convective conditions to take account of the skewed structure structure of the vertical component of the turbulence.
(ii) plume spread depends on the local wind speed and turbulence and thus depends on plume height. This contrasts with Pasquill-Gifford methods where plume spread is independent of height.
(iii) 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 values (single height or vertical profile), or statistically analysed data.
(iv) calculation of averages of mean concentration and deposition, and mean concentration percentiles for averaging times ranging from seconds to a year. For shorter averaging times (instantaneous upto 1 hour) estimates of fluctuations in the concentration, including peaks and probability of exceedence of concnetration thresholds, are included.
(v) a number of complex modules allow for the effects of plume rise, complex terrain, buildings, coastlines, marine boundary layers, a kinetic-chemistry model for wet deposition of SO2 and HCl, NOx chemistry and radioactive decay including gamma dose.
(vi) In complex terrain plume impaction and releases into regions of recirculating flow are modelled.

Model limitations/approximations

Rapidly changing weather conditions (timescales less than 1 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

Calculated at the mean plume height.

Turbulence

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

Deposition

Deposition and scavenging based on deposition velocity (species, particle size, wind velicity and surface roughness dependent) and washout coefficient. Option to use a □Falling Drop□ model of kinetics and chemistry for wet deposition of SO2 and HCl.

Chemistry

Coupled NO, NO2 and O3 chemistry for prediction of NO2 concentrations.

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 comprise: 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.

Emissions

Mass of pollutant emitted per second, or total mass for a puff release. Time varying emission factors can be provided, diurnal and monthly profiles or a time series with hourly values for one day.

Meteorology

A time series of up to five years can be used. Parameters are typically day, time, temperature, wind speed, wind direction, cloud cover or solar radiation, precipitation rate and relative humidity.

Topography

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

Initial conditions

The model does not incorporate initial or boundary conditions.

Boundary conditions

The model does not incorporate initial or boundary conditions (except background concnetrations of chemical species may be utilized).

Data assimilation options

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Output quantities

Mean concentration of pollutants for averaging times ranging from 10 minutes to 1 year (or more). Percentiles of concentration where required. Shorter averaging times treated with concentration fluctuation (probabilistic)model. Dry and wet deposition.

User interface availability

Windows (XP, Vista, 7). User interface includes ADMS 4 Mapper plus a link to a Geographical Information System (ArcGIS and MapInfo) and to Surfer plotting package.

User community

Environment Agencies, Government Departments, Environmental Consultancies, Industry (including large industrial and power generating companies), universities and research institutes.

Previous applications

1.

Application type

Episodes

Application description

Title & reference:

Validation of the UK-ADMS Dispersion Model and Assessment of its Performance Relative to R-91 and ISC using Archived LIDAR Data, (1995) Study commissioned by Her Majestys Inspectorate of Pollution, published by the Environment Agency. See Appendix C.

Short description:

Concentrations due to emissions from two cement works chimneys were investigated using LIDAR and modelling. Met data measurements local to the dispersion site were made.

Model performance:

Comparison of modelled and LIDAR results showed the importance of modelling short term fluctuations when determining performance against the 15 minute average standard for SO2.

Documentation status

Level 1. Documentation in English.

Technical Specification describing model algorithms and User Guide (manual)including worked examples available to download from www.cerc.co.uk

The User Guide is also supplied with model.

Validation and evaluation

Level 2. Industrial models validated against data when available.

Concentration predictions validated against all standard datasets (Prairie Grass, Kinciad, Indianapolis etc). Additional comparisons with LIDAR, hills &/or buildings field data (AGA, Alaska North Slope, Baldwin, Cinder Cone Butte, Clifty Creek, EOCR, Hogback Ridge, Lovett, Martins Creek, Millstone, Tracy, Westvaco) and wind tunnel data (Robins and Castro, Snyder, Warehouse fires, Lee Wind Tunnel, see references).

Model intercomparison

ADMS has been involved since the start in model inter-comparisons run under the title: Initiative on *Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes* www.harmo.org

The initiative established common data sets and and common tools for analysis of model performance.

CERC and others undertake other model inter-comparisons when possible as part of the model

verification and validation process and these are published when possible on www.cerc.co.uk
Relevant reference:
Hanna SR, Egan BA, Purdum J and Wagler J (1999) Evaluation of the ADMS, AERMOD and ISC3 Models with the Optex, Duke Forest, Kincaid, Indianapolis and Lovett Field Data Sets. International Journal of Environment and Pollution (Volume 16, Nos. 1-6, 2001)
Models used:
ADMS 3, AERMOD, ISC3
Datasets used:
Optex, Duke Forest, Kincaid, Indianapolis, Lovett Field
Model performance:
Analysis of the model performance measures suggest that ISC3 typically overpredicts, has a scatter of about a factor of three, and has about 33% of its predictions within a factor of two of observations. The ADMS performance is slightly better than the AERMOD performance and both perform better than ISC3. On average, ADMS underpredicts by about 20% and AERMOD underpredicts by about 40%, and both have a scatter of about a factor of two.
ADMS and AERMOD have about 53% and 46% of their predictions within a factor of two of observations, respectively. Considering only the highest predicted and observed concentrations,ISC3 overpredicts by a factor of seven, on average, while ADMS and AERMOD underpredict by about 20%, on average.

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 15 minute 99.9th percentile limit for SO2 by setting the Averaging Time in the Set Up screen of ADMS 4 to 15 minutes and using either a year of hourly sequential meteorological data or 10 years of statistical meteorological data in the calculation. In the Outputs screen of ADMS 4 the user should select Long term Average and click on Calculate Percentiles. The 99.9th percentile should be entered so that concentrations in the *.glt file can be compared directly to the limit. Calculated concentrations can be compared to other limits and guidelines by selecting the appropriate Averaging Time and percentile to be calculated.
- **Q:** Where can one obtain suitable meteorological data format use in ADMS 4 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 4. 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 4.
- **Q:** Can real map co-ordinates be used to locate the source positions in ADMS 4?
  A: Yes. The model can use UK 6 figure co-ordinates or any other co-ordinates converted to metres. Output can be plotted in metres or latitude-longitude.

Portability and computer requirements

Portability

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

CPU time

Very fast, several minutes for the annual average and percentiles for a single source.

Storage

Typically 0.5GB

Availability

Available commercially. Contact enquiries@cerc.co.uk

Summary description of model ADMS 5

Policy issue

- Air toxics
- Industrial pollutants
- Chemical emergencies

Application type

- Air quality assessment
- Regulatory purposes and compliance
- Policy support
- Emergency planning
- Scientific research

Model output

- Concentrations
- Deposition fluxes
- Exposure

Type of air pollution source

- Emissions from the stack of a plant (point source)
- Traffic emissions (line source)
- Area - volume source
- Multiple source

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)

Form of release

- Sulphur Dioxide (SO2)
- Carbon monoxide (CO)
- Nitrogen Oxides (NOx)
- Volatile Organic Compounds (VOCs)
- 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
- Stochastic models

Duration of the simulation

- Up to 10 minutes
- 10 minutes to 1 hour
- 1 to 24 hours

Computer Platform

- PC

References about model development (up to 5)

- CERC (2007), ADMS 4 Flat terrain validation: Kincaid, Indianapolis & Prairie Grass. www.cerc.co.uk or CERC, 3 Kings Parade, Cambridge, CB2 1SJ.
- Robins A. and, McHugh CA (1999), Development And Evaluation of The ADMS Buildings Effects Module. International Journal of Environment and Pollution (Volume 16, Nos. 1-6, 2001).
- 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 pp1937-1953.

Other references

- CERC (2010), ADMS 4 Technical Specification, www.cerc.co.uk or CERC, 3 Kings Parade, Cambridge, CB2 1SJ.
- CERC (2007), ADMS 4, validation documents for 18 validation data sets www.cerc.co.uk or CERC, 3 Kings Parade, Cambridge, CB2 1SJ.
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- Dyster SJ, Thompson DJ, McHugh CA and Carruthers DJ. (1999), Turbulent Fluctuations And Their Use in Estimating Compliance Standards And In Model Evaluation. International Journal of Environment and Pollution (Volume 16, Nos. 1-6, 2001).
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- 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 Majesty s Inspectorate of Pollution (published by DoE). DoE/HMP/RR/95/022