A review of useful and currently used computer modeling codes for radiological and chemical airborne releases

Computer Modeling Codes for Radiological and Chemical Airborne Releases

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Abstract: *Brief descriptions are provided for commonly used computer codes for estimating the consequences of atmospheric releases of radionuclides and chemicals. Different levels of sophistication and input detail are necessary for emergency response versus emergency planning. Health Phys. 81(Supplement):S15–S17; 2001*

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RADIONUCLIDES—EMERGENCY RESPONSE

Codes in this area should be fast, easy to use, and not require much input information. Typically used codes include HOTSPOT, RASCAL, and ARAC. These three bound the range of options

HOTSPOT health physics codes were created to provide health physics personnel with a fast, field-portable calculational tool for evaluating accidents involving radioactive materials. HOTSPOT codes are a first-order approximation of the radiation effects associated with the atmospheric release of radioactive materials. HOTSPOT programs are reasonably accurate for a timely initial assessment. HOTSPOT uses the well-established Gaussian Plume Model, which is widely used for initial emergency assessment or safety analysis planning of a radionuclide release. The dosimetric methods of ICRP Publication 30 have been used. Four general programs, PLUME, EXPLOSION, FIRE, and RESUSPENSION, calculate a downwind assessment following the release of radioactive material resulting from a continuous or puff release, explosive release, fuel fire, or area contamination event. Other programs deal with the release of plutonium, uranium, and tritium to expedite an initial assessment of accidents involving nuclear weapons. Additional programs estimate the dose commitment from inhalation of any one of the radionuclides listed in the database of radionuclides, calibrate a radiation survey instrument for ground survey measurements, and screen plutonium uptake in the lung. The HOTSPOT codes are fast, portable, easy to use, and fully documented. The codes have been extensively used since 1985. More detail is available at the Hotspot Health Physics Codes Web site http://www.llnl.gov/nai/technologies/hotspot/.

RASCAL

RASCAL—Radiological Assessment System for Consequence Analysis—was developed for use by U.S. Nuclear Regulatory Commission (NRC) staff who respond to power reactor accidents and other radiological emergencies. RASCAL, Version 2.2 (April 1998 release), estimates reactor source term, atmospheric transport, and doses resulting from radiological emergencies and can be used to assist in making protective action decisions.

The code system is comprised of a main batch file, executables, and data files. RASCAL 2.2 includes a "close-in" straight-line Gaussian plume model that computes doses at distances from 25 to 800 m. A lagrangian puff model is used for longer distances. Additional capabilities include the ability to enter isotopic source terms in mass units and a simple model of the toxicity of UF_6. Because RASCAL is designed for power reactors, it includes reactor release estimates. The NRC

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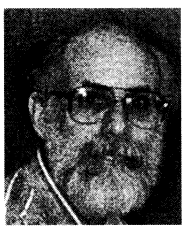

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prefers RASCAL over many conventional dose assessment models because it can be used to estimate releases by unmonitored pathways or to project releases based on accident progression alone. More information is available at the Radiological Accident Modeling for Emergency Response Web page http://www.cad.ornl.gov/cad_cp/text/als.html.

ARAC

Users requiring more sophisticated modeling capabilities, e.g., complex terrain, multi-location real-time wind field data, etc., are directed to such capabilities as the Department of Energy's ARAC computer codes. The Atmospheric Release Advisory Capability (ARAC) is operated by the University of California's Lawrence Livermore National Laboratory. It can map the probable spread of the contamination to help emergency response officials decide what response measures are needed. ARAC's main function is to provide near real-time assessments of the consequences of accidental or potential radiation releases by modeling the movement of hazardous plumes. ARAC is a centralized, worldwide emergency response service, not typically run by responders at the site of the emergency. See the ARAC Web site http://www.llnl.gov/ees/NARAC/.

RADIONUCLIDES—EMERGENCY RESPONSE PLANNING

Codes in this class require much more input information and typically will also allow you to perform uncertainty analyses. However, they typically run on climatic data rather than real time inputs, and so are not appropriate for emergency response.

GENII

The GENII system includes the capabilities for calculating radiation doses following chronic and acute releases, with options for annual dose, committed dose, and accumulated dose. Radionuclide transport via air, water, or biological activity may be considered. Air transport options include use of an effective stack height or calculation of plume rise from buoyant or momentum effects (or both). Building wake effects can be included in acute atmospheric release scenarios. Transport is modeled using the 95th percentile projected air concentrations, derived using the Gaussian plume model. Acute dose calculations are performed by the season in which the release occurs, to obtain a range of consequences for an accidental release. The code does not provide risk estimates for health effects to individuals or populations; these can be obtained external to the code by applying appropriate risk factors to the effective dose equivalent or organ dose. A stochastic version of GENII developed by Sandia National Laboratories is also available, GENII-S. GENII is ageing (gracefully?) and a new version is under development. See the GENII–The Hanford Environmental Radiation Dosimetry Software System Web page http://www.pnl.gov/eshs/software/genii.html.

MACCS2

The MELCOR Accident Consequence Code System (MACCS) was developed under the sponsorship of the U.S. Nuclear Regulatory Commission to simulate the accidental release of a plume of radiological materials to the atmosphere and estimate consequences associated with the release. The principal phenomena considered in MACCS are atmospheric transport and plume depletion, exposure pathway assessment and subsequent dose analyses, mitigative actions based on dose projection, early and latent health effects, and economic costs. The MACCS2 applications include probabilistic risk assessment (PRA) and radiological dose assessment for safety analyses and environmental studies, the types of analyses required for SAR and BIO support, with guidance toward problems that consider the food ingestion and health effect risks. For more information, go to the RSICC Code Package CCC-652 Web page http://epicws.cped.ornl.gov/codes/ccc/ccc6/ccc-652.html.

CHEMICALS—EMERGENCY RESPONSE AND PLANNING

Chemical codes tend to have simpler transport models (usually Gaussians) and can be used for both response and planning.

EPIcode

The Emergency Prediction Information (EPI) code is a commercially available computer code for modeling routine or accidental releases of hazardous chemicals to the environment (Homann 1988). It seems to be routinely used for NEPA calculations within the DOE system, as well as emergency response centers. I am not familiar with it, and it does not appear to have any on-line documentation.

CAMEO®

CAMEO® is a system of software applications used widely to plan for and respond to chemical emergencies. It is one of the tools developed by EPA's Chemical Emergency Preparedness and Prevention Office (CEPPO) and the National Oceanic and Atmospheric Administration Office (NOAA) of Response and Restoration, to assist front-line chemical emergency planners and responders. CAMEO is used to access, store, and evaluate information critical for developing emergency plans. In addition, CAMEO supports regulatory

compliance by helping users meet the chemical inventory reporting requirements of the Emergency Planning and Community Right-to-Know Act (EPCRA, also known as SARA Title III). CAMEO also can be used with a separate software application called LandView® to display EPA environmental databases and demographic/economic information to support analysis of environmental justice issues. The CAMEO system integrates a chemical database and a method to manage the data, an air dispersion model, and a mapping capability. All modules work interactively to share and display critical information in a timely fashion. The CAMEO system is available in Macintosh and Windows formats. For more information, see the CAMEO Web site http://www.epa.gov/ceppo/cameo/index.htm.

CHARM

Radian International LLC's CHARM® software is a Complex Hazardous Air Release Model software program that calculates and predicts the movement and concentration of airborne plumes from released chemicals; thermal radiation from BLEVEs, pool fires, and jet fires; and overpressures from vapor cloud explosions and vessel failures. Population impacts can be determined for each impact type. The software is an MS Windows program and allows impact footprints to be overlaid on maps for console display or print. A number of tabular and graphical outputs are available. For more information, visit the CHARM Web site http://charm.radian.com.

ISC-3

The EPA's Industrial Source Code series of models provides good capability for both long-term and short-term releases. ISCST3 (ISC-short term) is useful for most types of releases. This is available at EPA's Support Center for Regulatory Air Models Web site http://www.epa.gov/scram001/.

COMBINED CHEMICAL AND RADIONUCLIDE MODEL

The Department of Defense has developed a complex response model for battlefield application. It is a little overwhelming for most planning uses.

HPAC

Hazard Prediction & Assessment Capability (HPAC) is a Gaussian puff model, which uses a second order closure model for the treatment of the turbulence component. HPAC can be used to predict hazards from nuclear, biological, chemical, and radiological (NBCR) weapons and facilities. It is a forward-deployable (i.e., counter proliferation), counter force disaster preparedness capability. HPAC models atmospheric dispersion of vapors, particles, or liquid droplets from multiple sources, using arbitrary meteorological input ranging from a single surface wind speed and direction up to four-dimensional gridded wind and temperature field input. HPAC 3.1 readily treats hazard scenarios involving nuclear, chemical, and biological hazards from facilities, weapons, accidents, etc. There are six user-friendly incident and source term description modules: Nuclear Facility, Biological Facility, Chemical Facility, Nuclear Weapon, Chemical/Biological Weapon, and Radiological Weapon. Find it at the HPAC Standard Operating Procedure Web page http://www.dtra.mil/td/hpac/td_hpac.html.

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REFERENCE

Homann Associates, Inc. Emergency Prediction Information Code (EPICode). Fremont, CA; 1988.