GIS Based Planning and Management Support System for Emergency Events involving Atmospheric Releases of Hazardous Materials

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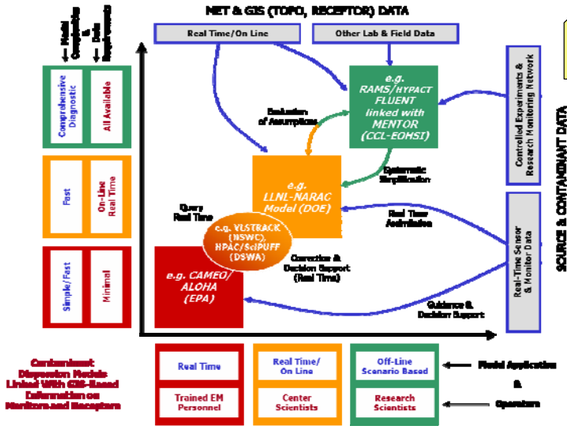
Summary

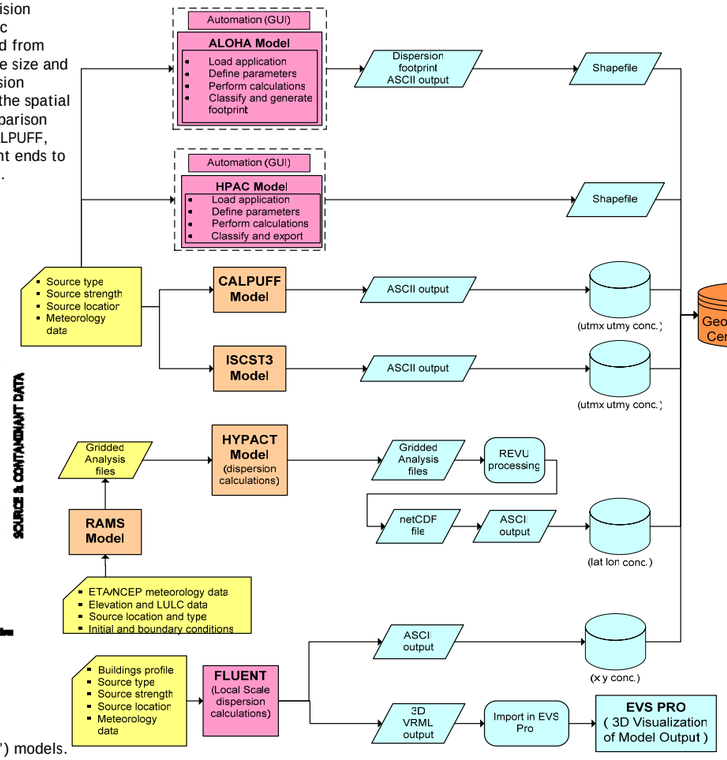
Numerous atmospheric dispersion models, with a wide range of features are available for assessing potential emergency response situations. A rational planning decision support system for emergency events must consider a hierarchy of atmospheric dispersion models for emergency response analyses. Appropriate data gathered from various models have to be organized and displayed logically to determinate the size and scope of emergency management programs. The GIS-based planning and decision support system presented here can utilize alternative models to characterize the spatial extent of a hazardous release under plausible scenarios, and enable easy comparison and sharing of results. Models in this system include ALOHA, ISC, AERMOD, CALPUFF, and HPAC. Model platform dependent issues are mitigates using GIS-based front ends to appropriately store and visualize different model outputs in a uniform manner.

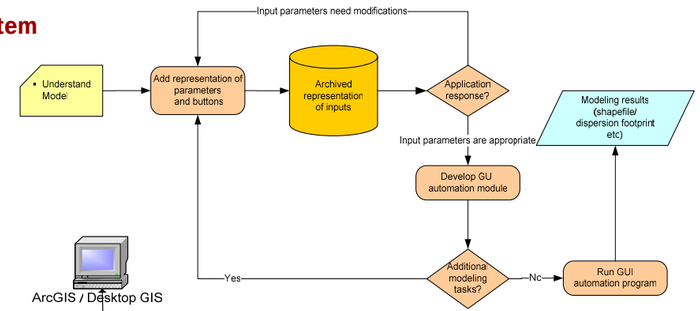
Multiple Scales/Levels of Atmospheric Dispersion Models for Emergency Response Support



Hierarchy of atmospheric dispersion models for emergency response analysis: Simpler models need to be evaluated through both available data from field experiments and comparisons with more detailed ("research laboratory grade") models.

Automated GIS-based Planning and Management Support System





GIS-Based Support System

Desktop GIS Applications Supported: ArcMap, ArcView, QuantumGIS, etc.

- full GIS functionalities such as spatial query of modeling results
- customized display of spatially-based modeling results

Geodatabases Supported: ArcSDE, Oracle Spatial, PostGIS, etc.

- modeling results archived in shapefiles, layers, etc.
- spatial data saved in multiple formats (vectors, rasters, CAD, etc.)
- centralized access to spatial data by desktop and web applications

Web-Based Map Servers Supported: ArcIMS, MapServer, etc.

- allow access/visualization to spatially-based modeling results through web browser
- provide development interfaces that can be used to create additional web-based analysis and visualization tools

GUI Automation Sub-System

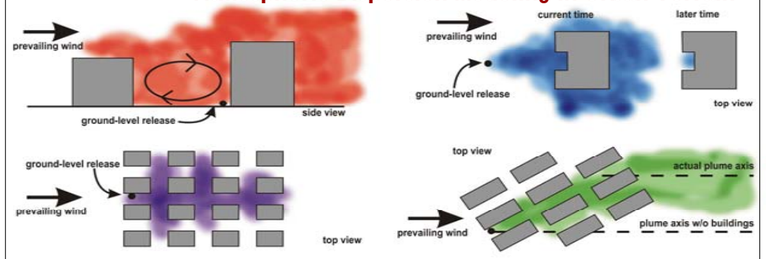
Problem:

- Emergency event response planning typically requires multiple model simulations to generate possible outcomes for various scenarios.
- A series of repetitive commands need to be executed manually for models that are purely GUI-based, without a scripting interface
- This increases chances for human errors, and could hinder the decision-making process, especially when time is limited

Solution:

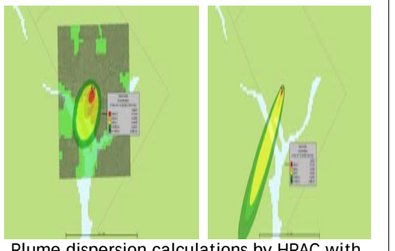
- The Graphical User Interfaces (GUI) automation sub-system will facilitate systematic automation of several GUI-based dispersion models
  - Substantial time and effort savings by replacing manual input of recurring combination of keystrokes and mouse events with a script

Atmospheric Dispersion Modeling in Urban Terrain

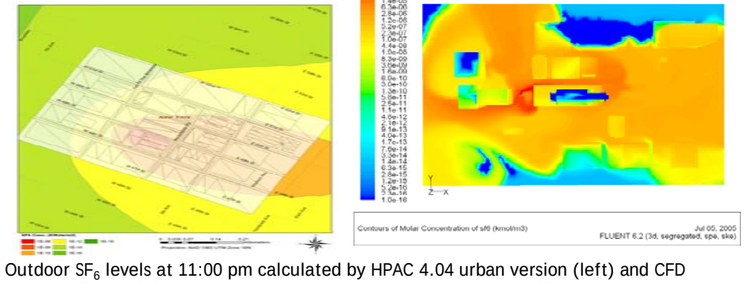


Potential effect of buildings on plume dispersion in urban areas: for the same prevailing wind characteristics and chemical release, the plume profile can be significantly different, depending on the building profiles around the release location

Five urban locations for which HPAC provides urban terrain data:
New Orleans, New York, Oklahoma City, Salt Lake City, and Washington DC.



Plume dispersion calculations by HPAC with (a) urban option selected (left), and (b) without the urban option (right)



Outdoor SF_6 levels at 11:00 pm calculated by HPAC 4.04 urban version (left) and CFD platform Fluent 6.2.16 (right), for a hypothetical release of 1 g/s SF_6 over a period of eight hours, starting at 2:00 pm on June 21, 2004 in an urban setting. Meteorological conditions are wind speed of 4.2 m/s, wind blowing from 290 degrees (clockwise from north), and scattered clouds. The HPAC simulations were preformed with urban settings, and included both the Urban Dispersion Model (UDM) and the Urban Wind Field Module (UWM).

Modeling Results Obtained with an Automated GIS-based Planning and Management Support System

Areal Locations of Hazardous Atmospheres (ALOHA) developed by NOAA

- *Provides "levels of concern"* at downwind locations of the chemical release based on the toxicological/physical characteristics of the released chemical, atmospheric conditions, and source strength and release pattern
- *Displays a "footprint" plot* of the area downwind of a release where concentrations may exceed user-set threshold levels
- *Simple and fast*, is used by trained emergency responders

CALifornia PUFF (CALPUFF) model developed by Earth Tech

- *Multi-layer, multi-species, non-steady-state* puff dispersion model
  - simulates effects of time- and space-varying meteorological conditions on transport, linear transformation and removal
- *Includes algorithms for sub-grid scale effects* (e.g. terrain impingement) as well as longer range effects (e.g. wet scavenging, dry deposition, chemical transformation, and visibility effects of particulate matter concentrations)
- *Spatial extent:* tens to hundreds of kilometers
- *Temporal resolution:* hourly

Industrial Source Complex (ISC)

- Developed by USEPA
- Steady-state Gaussian plume model which can be used to assess pollutant concentrations from a wide variety of sources associated with an industrial complex
- Accounts for settling and dry deposition of particles; downwash; point, area, line, and volume sources; plume rise as a function of downwind distance; separation of point sources; and limited terrain adjustment.
- Operates in both long-term and short-term modes.
- Hourly concentrations
- Up to 50 kilometer modeling domain

Regional Atmospheric Modeling System/Hybrid Particle And Concentration Transport Model (RAMS/HYPACT)

- Developed by Colorado State University and ASTER
- RAMS is a multipurpose, prognostic numerical prediction model designed to simulate atmospheric circulations spanning scales from the hemisphere down to large eddy simulations of the planetary boundary layer
- RAMS provides several physical options of hydrostatic to non-hydrostatic codes
- HYPACT initializes meteorological conditions from RAMS and performs dispersion calculations with specified source type for different grid resolutions
- Temporal resolution: minutes
- Modeling domains range from a few kilometers to an entire hemisphere and the resolution ranges from less than a meter to the order of a hundred kilometers

Hazard Prediction and Assessment Capability (HPAC)

- Developed by Defense Threat Reduction Agency (DTRA)
- HPAC estimates hazards associated with releases from incidents such as Nuclear Facility Accidents, Nuclear and Biological Weapon Explosions and Chemical facility damage (NBC hazards)
- HPAC includes Urban Dispersion Model (UDM) and Urban Wind Model (UWM)
- HPAC has micro swift and CFD-like urban option along with SCIPUFF to calculate dispersion plume
- HPAC has Wx component tool to import real-time weather data from nearest weather station
- Every minute concentration
- Modeling domains can be extended to hundreds of kilometers and the resolution ranges from less than a meter to the order of a hundred kilometers

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