ARAC III:
Next Generation ARAC System

by

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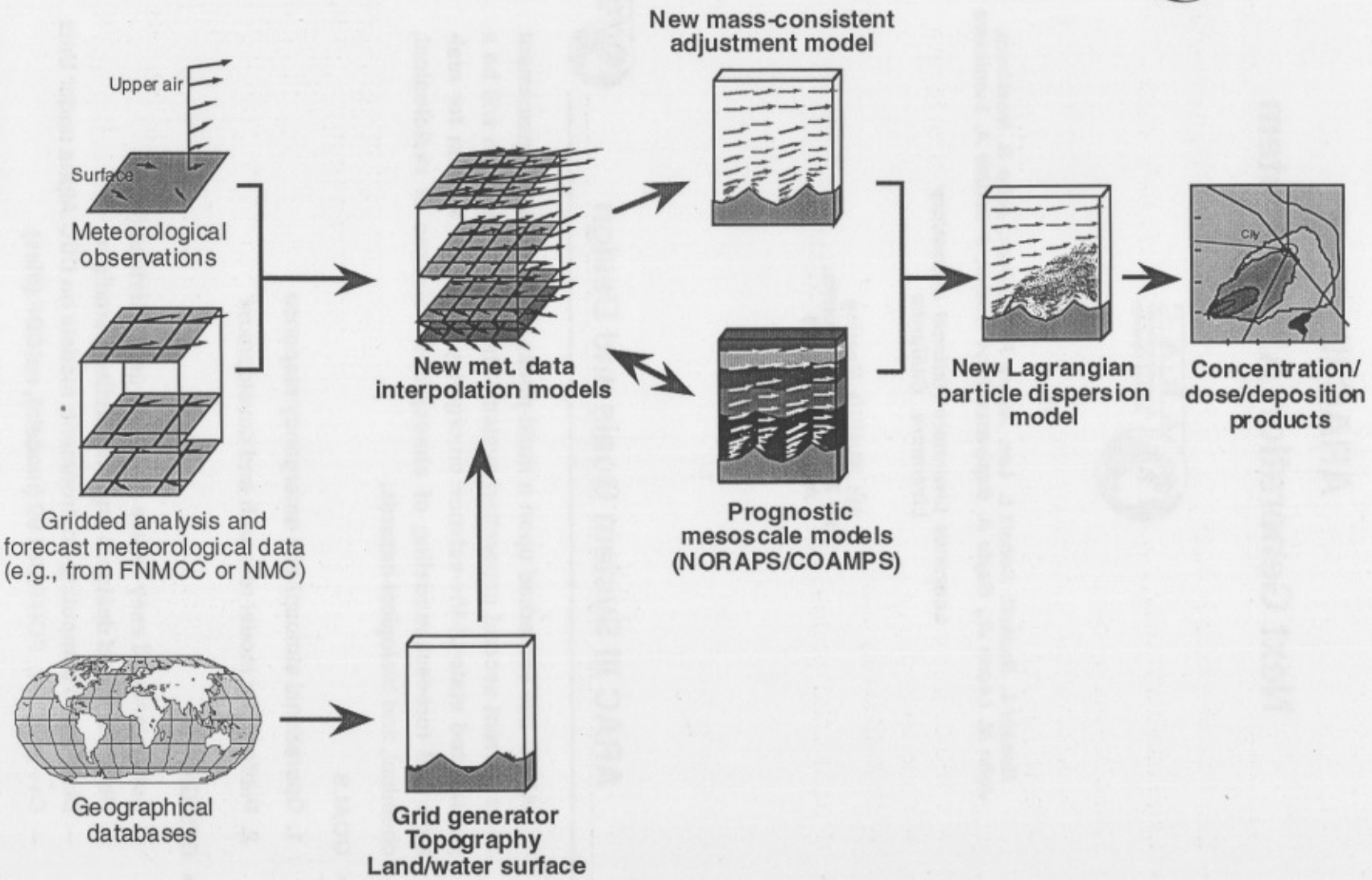
ARAC III System Goals and Design

ARAC has embarked upon a multi-phase redesign and replacement of its current second generation system. The ARAC III system will be a generalized state-of-the-science emergency response system for real-time and forecast modeling of atmospheric releases of radiological, chemical, and biological hazards.

- **GOALS**
  1. **Operational atmospheric emergency response**
  2. **Platform for model research and development**
- **DESIGN**
  - **Consistent and easy-to-use graphical user interface (GUI)**
  - **Object oriented design & implementation paradigm**
  - **Distributed computing environment; models on DEC Alpha under Unix**
  - **C++ (system), FORTRAN 90 (models), netCDF (files)**

ARAC III Modeling System



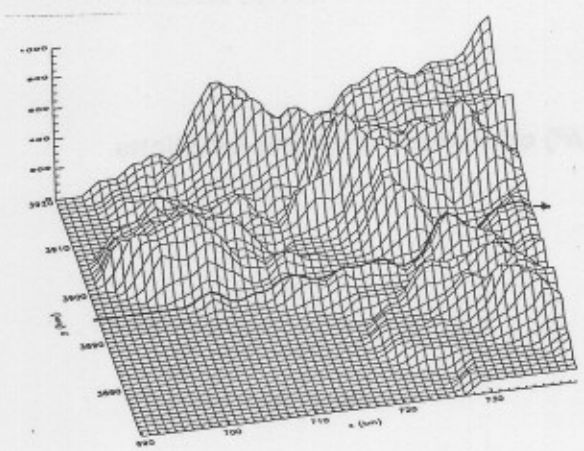
Geographical Databases

- Worldwide topographic elevation databases
  - ~10 km (5 arc-min): US Geophysical Data Center ETOPO5
  - ~1 km (30 arc-sec): US Geological Survey
  - ~0.1 km (3 arc-sec): Defense Mapping Agency Digitial Terrain Elevation Data
- Land-water masks from Digital Chart of the World (DCW) database
- Land use/land cover, soils, vegetation, and albedo databases
- Remote sensing data
  - Snow cover, soil temperature & moisture
  - Bi-weekly NDVI (Normal Difference Vegetation Index) from AVHRR
- Political, transportation, and hydrological data
  - DTED Gazetteer data: USGS Geographical Name Information System
  - Street centerline data: TIGER and DCW
  - Detailed facility maps: Digitized for ARAC sites
- Census data: population and agricultural statistics

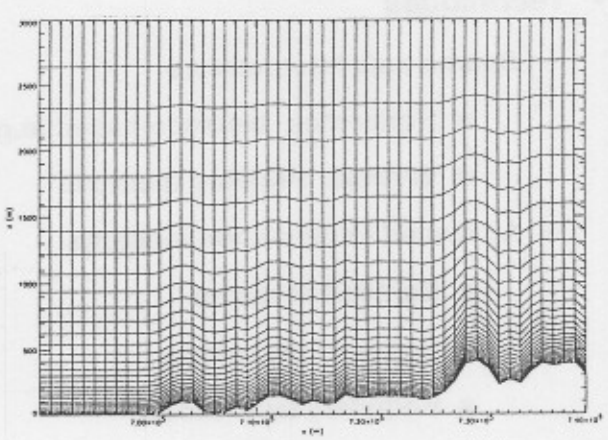
Grid Generator

- Interactive selection and visualization of dimensions & location

Continuous terrain



Variable horizontal & vertical (σ_z) grid



Example 51 x 51 x 31 grid for PG&E Diablo Canyon, Calif. DOPPTEX Study

Real-time Meteorological Data

- Air Force Global Weather Central (AFGWC)
  - Observational data — Sfc every hour (over seas 3 hrs); Upr every 12 hrs
  - Gridded data — 381 km every 12 hrs
- Domestic Data Plus (DDP)
  - Observational data backup for US
- ARAC towers at supported sites every 15 min
- Fleet Numeric Meteorological and Oceanographic Center (FNMOC)
  - 1º gridded data — Global — Every 6 hrs out to 48 hr forecast
- National Weather Service (NWS)
  - AVN 1º gridded data — Global — Every 3 hrs out to 72 hr forecast
  - ETA 40 km data — US — Every 6 hrs out to 48 hr forecast

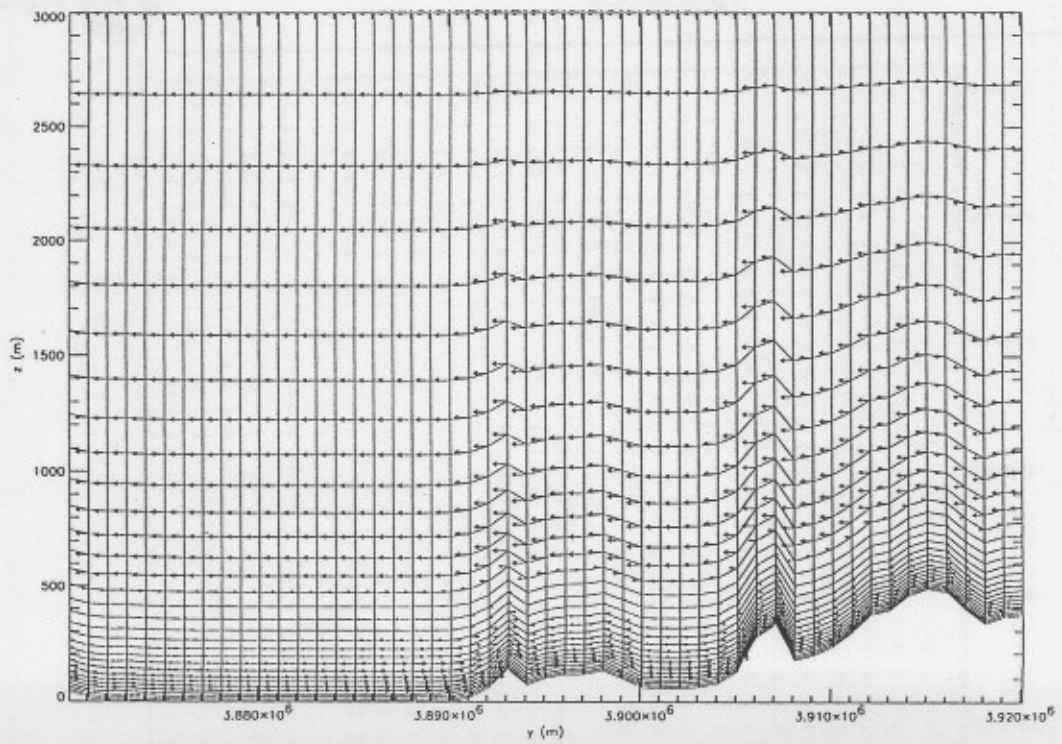
Meteorological Data Assimilation

- Dual purpose interpolation of met fields (wind, temp., pressure, precip.)
  1. For diagnostic analyses
  2. For prognostic model
- Techniques
  - Sparse data interpolators
    - ❊ Horizontal: distance-based (e.g. $1/r^2$) or station-weighting functions
    - ❊ Vertical: Profiling methods
  - Advanced interpolation methods
    - ❊ Barnes/Cressman
    - ❊ Optimal interpolation
    - ❊ Boundary layer model

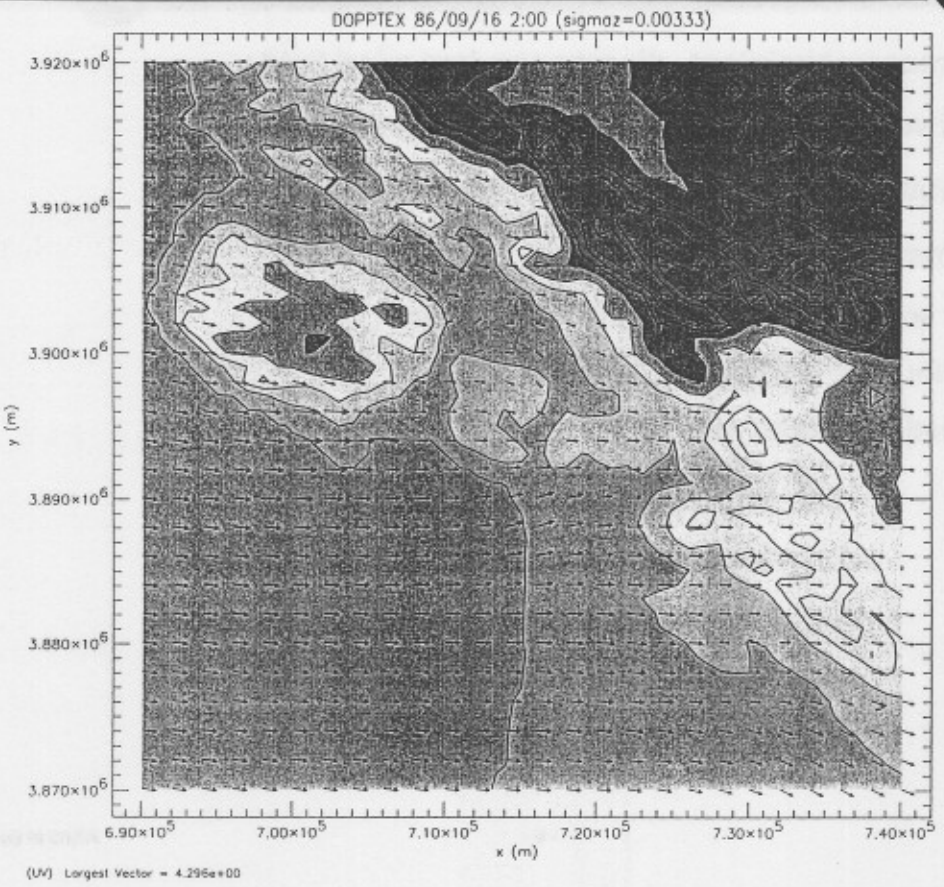
Diagnostic Wind Model

- Provides mass-consistent, divergence-free wind field
- Control of vertical versus horizontal adjustments
- Handles both free and fixed boundary conditions
- Finite element method
  - Greater solution accuracy than finite difference
  - Grid-point wind vectors
  - Preservation of input wind values

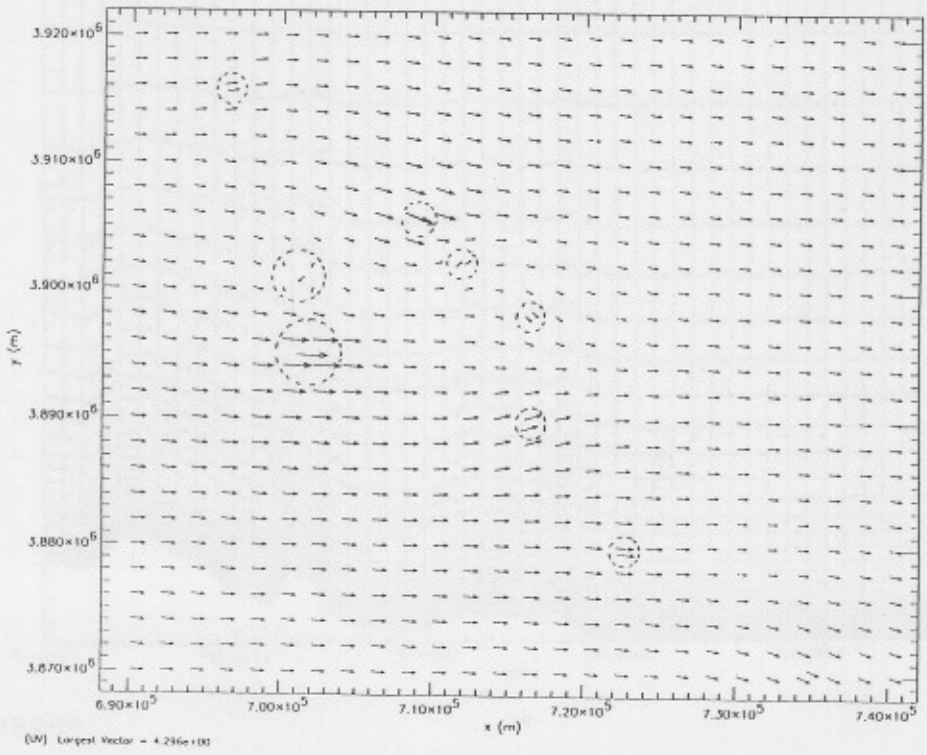
Example Diagnostic Wind Cross-Section - PG&E DOPPTEX



Example Diagnostic Wind Field - PG&E DOPPTEX



Preservation of Input Wind Values - PG&E DOPPTEX

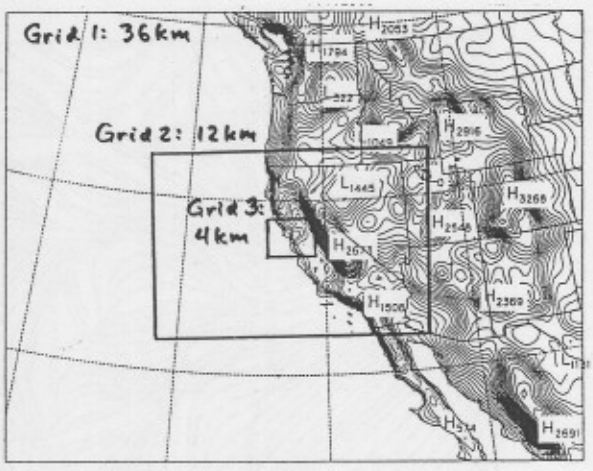


NORAPS Prognostic Meteorological Model

- Adapt Navy Operational Regional Forecast System (NORAPS)
  - Collaborate with Naval Research Laboratory (NRL)
  - Increase 3-way nesting to higher resolution (few km inner nest)
- Hydrostatic primitive equation model with selectable physics modules
  - Boundary layer and surface energy balance parameterization
  - 1-1/2 order turbulence closure
  - Cumulus cloud parameterization
  - Radiative transfer physics
- Initializate with regional or global datasets
  - NWS ETA US model (40 km)
  - Navy NOGAPS global model (1° or ~111 km)

NORAPS Example - S. F. Bay Area

Three-way nesting: 36 - 12 - 4 km

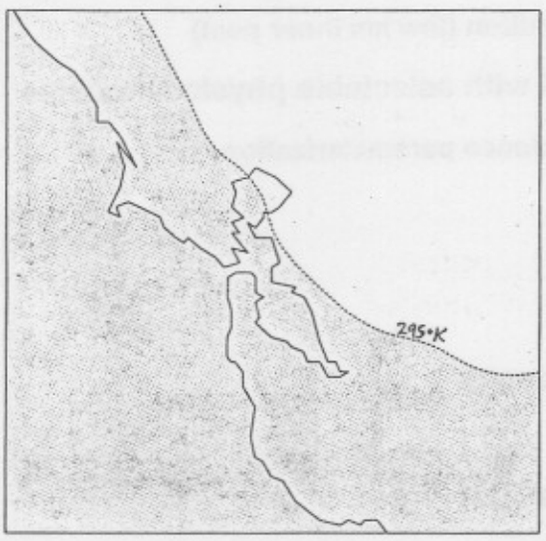


NORAPS Example - S. F. Bay Area

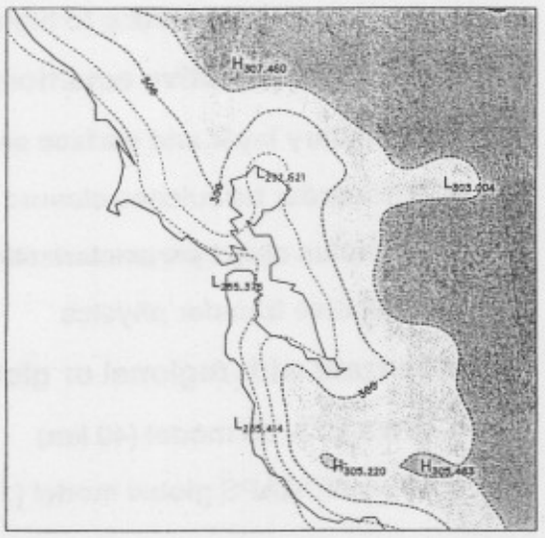
A·R·A·C Atmospheric Release Advisory Capability

23 June 1995 "Heat wave" case

Initial 1° gridded temperature



24-hour forecasted temperature

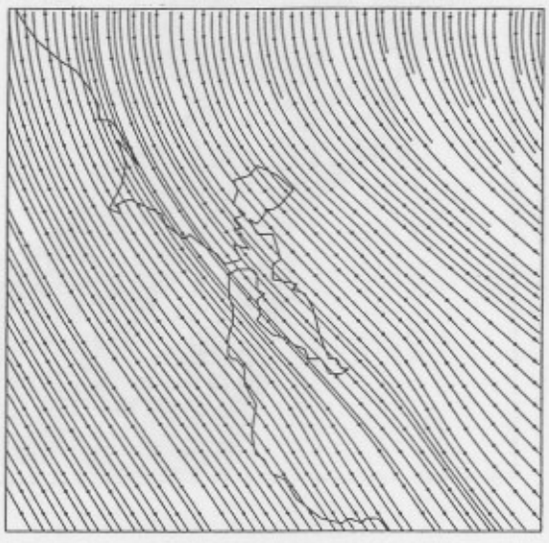


NORAPS Example - S. F. Bay Area

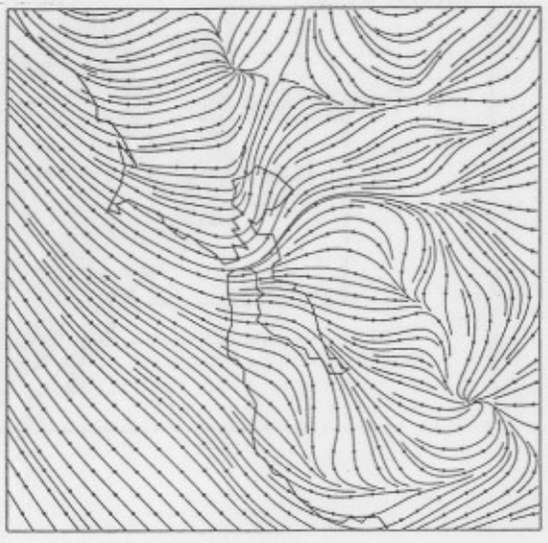
A·R·A·C Atmospheric Release Advisory Capability

23 June 1995 "Heat wave" case

Initial 1° gridded winds



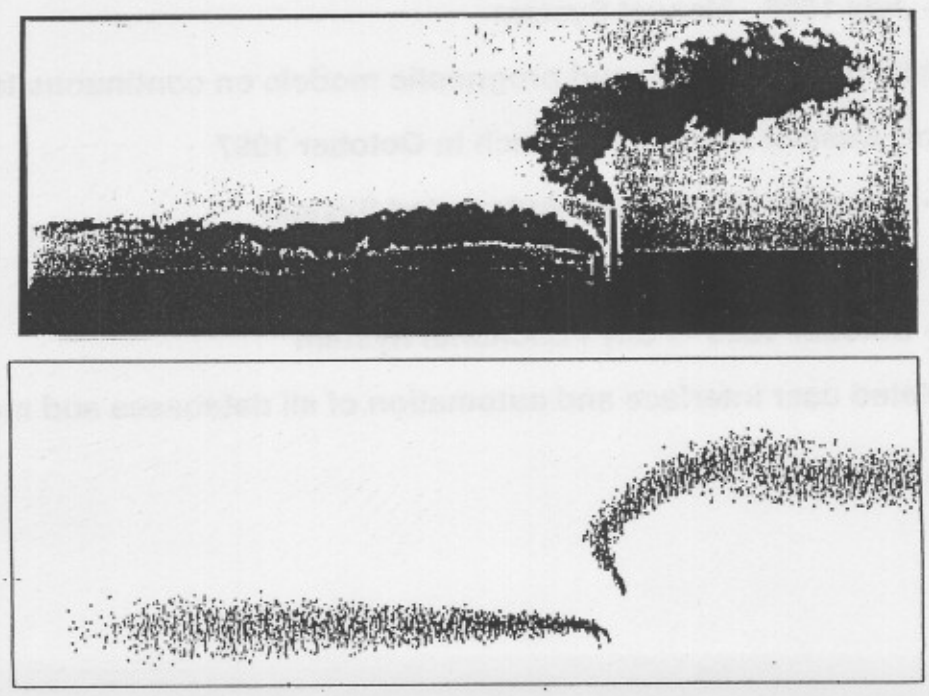
24-hour forecasted winds



Lagrangian Dispersion Model

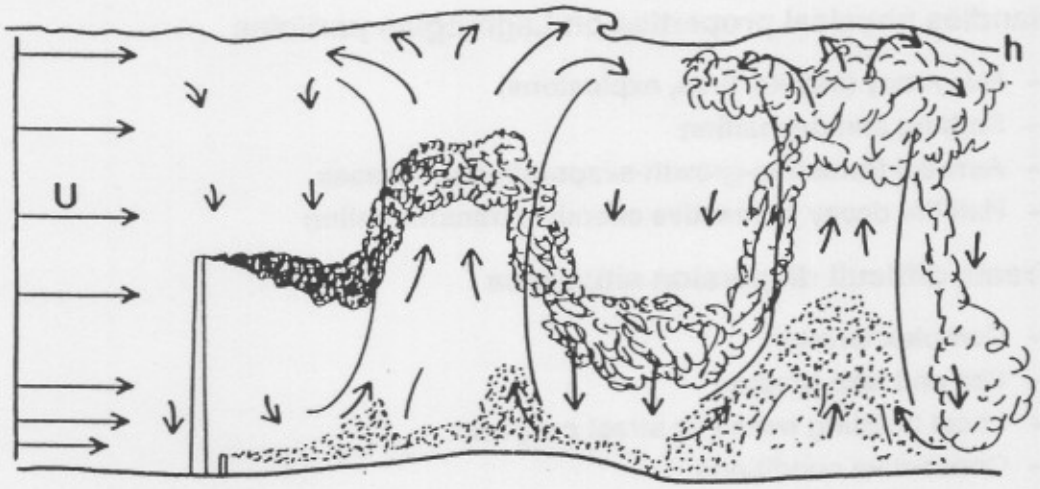
- Random displacement method (RDM)
  - Lagrangian and stochastic (e.g., Monte Carlo or Random Walk) diffusion
  - Independent of grid - no numerical diffusion
- Variety of horizontal and vertical diffusivity options
- Handles physical properties on Lagrangian particles
  - Buoyancy (stacks, fires, explosions)
  - Settling and deposition
  - Aerosol formation-growth-evaporation processes
  - Half life decay or reactive chemical transformation
- Treats difficult dispersion situations
  - Complex terrain
  - Sea and lake breezes
  - Local building wakes or street canyons
  - Convective conditions

Dispersion in Highly Sheared Sea Breeze



Dispersion in Convective Boundary Layer

Centerlines of *near-surface* sources tend to *ascend* while centerlines of *elevated* sources tend to *descend* due to higher probability of weak downdrafts and lower probability of strong updrafts



ARAC III Schedule

- Phase 1 - July 1996 - Manual System
  - Manually run diagnostic and prognostic models on continuous terrain
  - Support Cassini spacecraft launch in October 1997
- Phase 2 - February 1998 - Basic Automated System
  - Basic interaction between model stream completed
- Phase 3 - October 1999 - Fully Functional System
  - Completed user interface and automation of all databases and models