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RTFDDA-SCIPUFF Coupled Applications

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Dispersion Models and Modeling



- Nature of the problem
- Types of Models
- SCIPUFF



What is meant by T&D



Turbulence and Diffusion - the study of motions that lead to mixing in a fluid

(not what I'll talk about)

Transport and Dispersion - the application of T&D science to study materials that get mixed in a fluid

(what I'll try to focus on)



Nature of the Problem



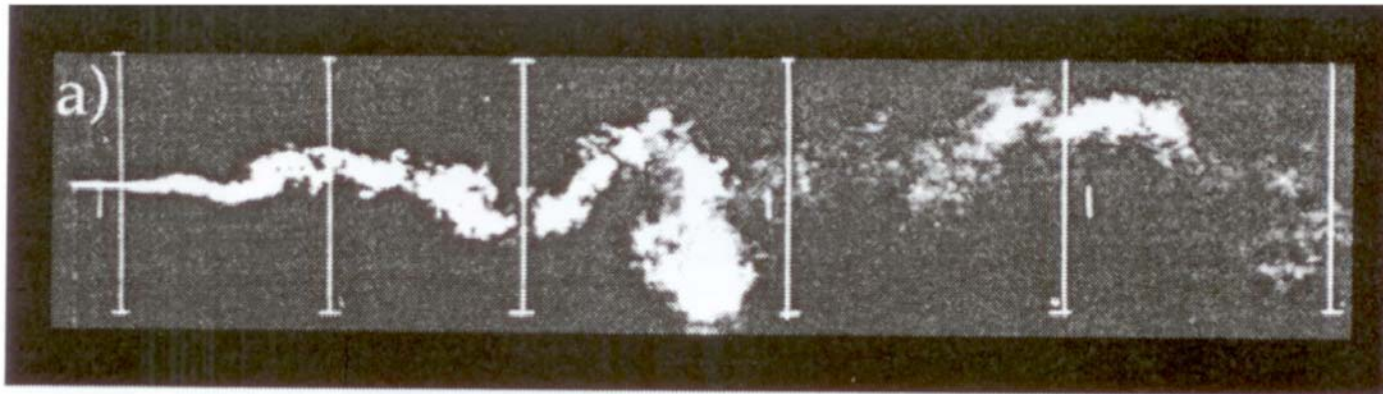
- Purpose
 - Regulatory, Emergency response
- Release Mechanics
 - Point, line, area
 - Instantaneous, continuous
- Type of material
 - Gas, aerosol, particulate
- Atmospheric Conditions
 - Stability, flow regime
 - Knowledge



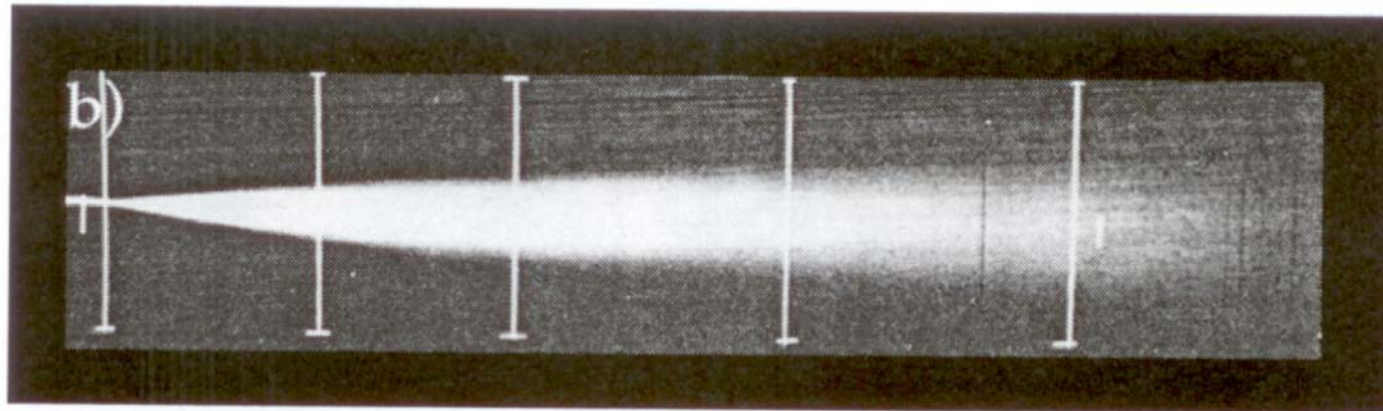
What are we simulating



Snapshot



Time average

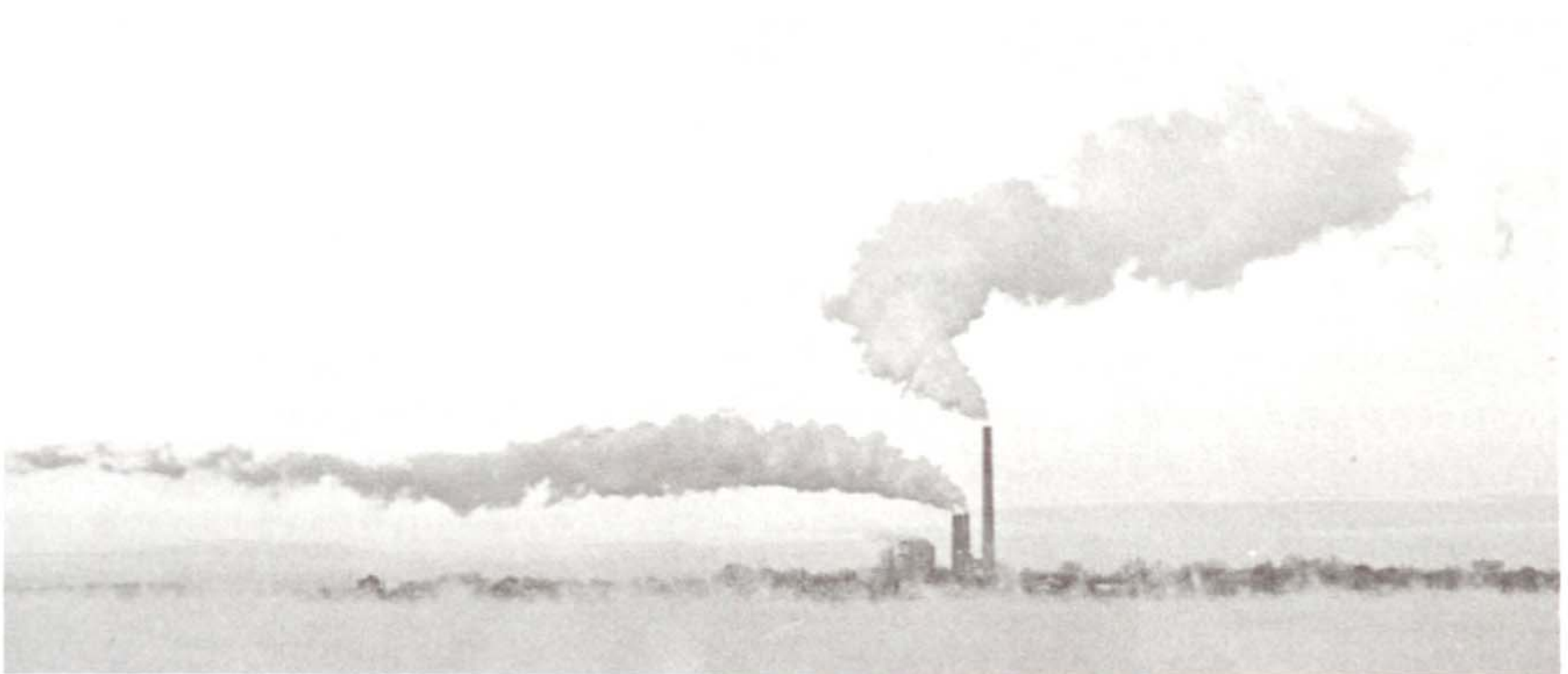




Complexity



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Gaussian Models



Plume or Puff

- *Continuous or instantaneous point source*
- *Uniform flow*
- *Homogeneous turbulence*
- *Mass conservation in plume*

$$\underline{c} = \frac{Q}{2 \cdot u \cdot y \cdot z} \exp \left[-\frac{y^2}{2 \cdot \sigma_y^2} \right] \exp \left[-\frac{z - H}{2 \cdot \sigma_z^2} \right] \exp \left[-\frac{z - H}{2 \cdot \sigma_z^2} \right]$$

- *Need to specify Q and σ , either parameterize or measure*



Gaussian Models



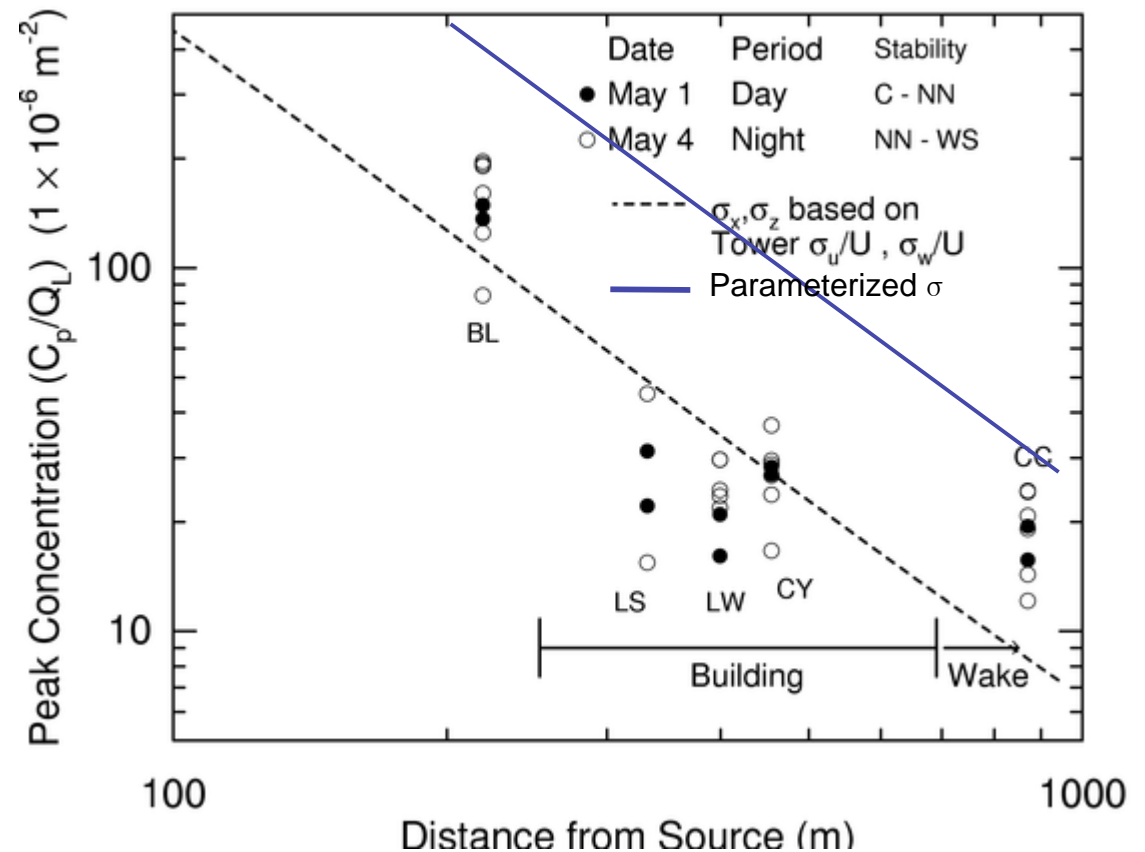
Advantages

- *Analytic*
- *Fast*
- *Regulatory*

Disadvantages

- *Simplified physics*
- *Limited applicability of design assumptions*

Peak Surface Concentration from TGA Monitors





Lagrangian Models



- Stochastic model of Lagrangian velocities (Monte-Carlo, Markov-chain)
- Material treated as a cloud of particles that move with the mean wind plus a random component based on the turbulence strength

$$\frac{dX}{dt} = U = \bar{U} + U'$$

$$U'_{t+\Delta t} = a U'_{t-\Delta t} + a^{2-1/2} \eta_t$$

$$a = \exp\left(-\frac{\Delta t}{T_L}\right)$$

- σ_t generally given by σ_x , σ_y , or σ_z
- η_t is a dimensionless random variable with mean of 0 and variance of 1
- T_L is the integrated Lagrangian time scale



Lagrangian Models

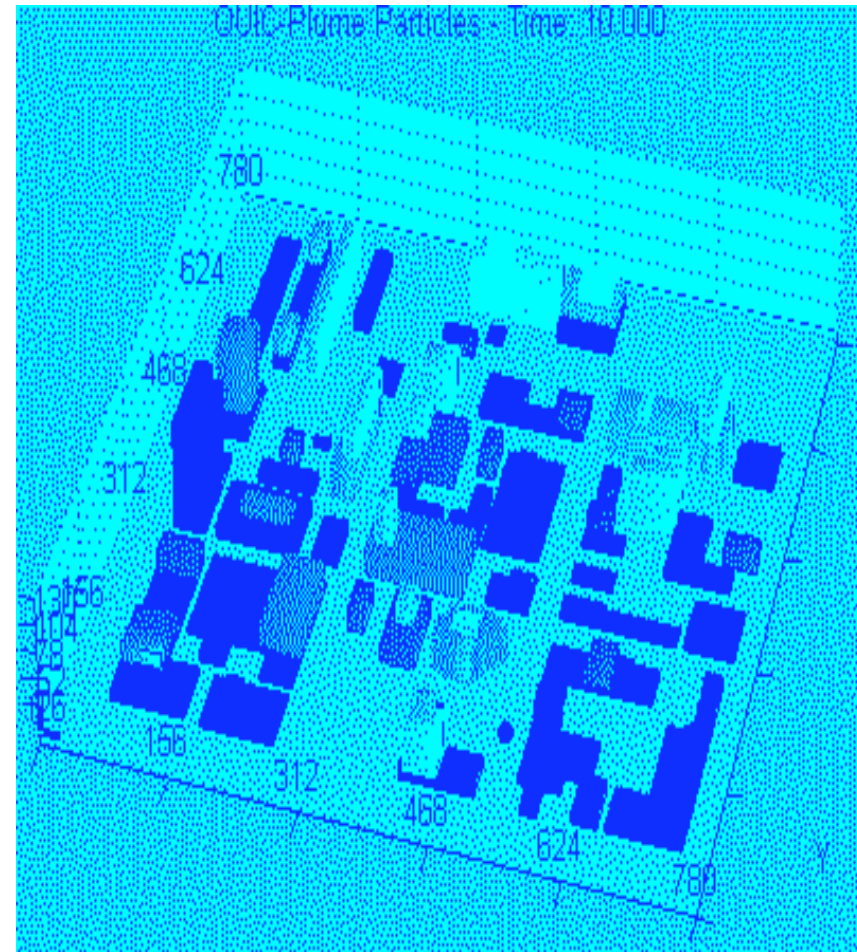


Advantages

- *Modifications for inhomogeneous turbulence and wind field*
- *Complicated sources/releases*
- *Treatment of buildings reasonably simple*

Disadvantages

- *Number of particles (runtime, concentration)*





Eulerian Models



Additional conservation equations added to mesoscale or LES models

Advantages

- *Detailed physics*
- *Chemistry*

Disadvantages

- *Resolution vs compute time*





Hybrid Models



Langrangian-Eulerian

Langrangian-Puff: SCIPUFF



T&D in RAL



- NSAP projects
 - ATEC, DARPA, DHS, GCAT,...
- Wind Models
 - RTFDDA
 - VDRAS/VLAS
 - QUIC-Urb mass conserving flow distortion
 - CFD-Urban RANS
- Plume Models
 - HPAC SCIPUFF Lagrangian-Puff
 - CALPUFF Lagrangian-Puff
 - QUIC-Plume Lagrangian Particle
 - AERMOD Gaussian Plume



What is SCIPUFF



- A Lagrangian-Puff transport and diffusion model for atmospheric dispersion applications
 - Computes concentration mean and variance
 - Wide range of CBRN release plume applications
 - Industrial air pollution studies
 - Forest fire plume studies



SCIPUFF Modes



- Stand-alone SCIPUFF that runs on all platforms
 - Not building aware
 - Good for operational range use
 - Can be the back-end engine for GUI and web-based coupled applications (e.g., Jvis, GCAT, GMOD)
- A component in PC-Windows based HPAC
 - GUI-based model setup
 - Detailed source models
 - Display
- Planned integration into JEM



GCAT SCIPUFF interface



GCAT

Home Job Manager New Job Search Job Visited Jobs

GCAT: Scipuff Job 249 > Scipuff Config > Incidents Setup > **Domains Setup** > Timeline Setup > Plots Setup > Output Setup

Scipuff

Scipuff Domains Setup

Select Scipuff Outermost Domain.

D1 D2 D3 Update map

Upload a new inner domain from namelist files or select the inner domain dragging a box on the map using the mouse.

Insert fraction of incident light that is reflected by the surface (albedo) and the ratio of surface sensible to heat flux to latent heat flux (bowen).

Albedo	Bowen
0.16	0.6

Inner domain boundaries.

NW	54.4663	-130.37
SE	41.5996	-115.29

Upload terrain (.ter) file.

Terrain File: /Users/marcel/d1/ngic_s

Copyright: ESRI, EarthSat, AND © ESRI MAPS copyright notice.

Mouse over the map to display coordinates

Welcome ncaruser
Your role is ncaruser

demouser

Log Off

Platforms Status

Display platform status

Visited Jobs

How to configure

Step 1: Config Setup
Scipuff54

Step 2: Release Incidents Setup
Name: RELEASE1
Material: TUL
Mass: 1.0
Latitude: 48.091
Longitude: -123.603
Height: 0.0
Time: 0.0
Type: I

Step 3: Domains Setup

Step 4: Timeline Setup
Start Date: May 19 11:00 UTC
End date: May 22 13:00 UTC
Obs years: 1999
Run over FDDA ensemble: true

Step 5: Plots Setup
Tularemia Infection: Probability
Tularemia Fatalities: Probability
TUL Surface Dosage

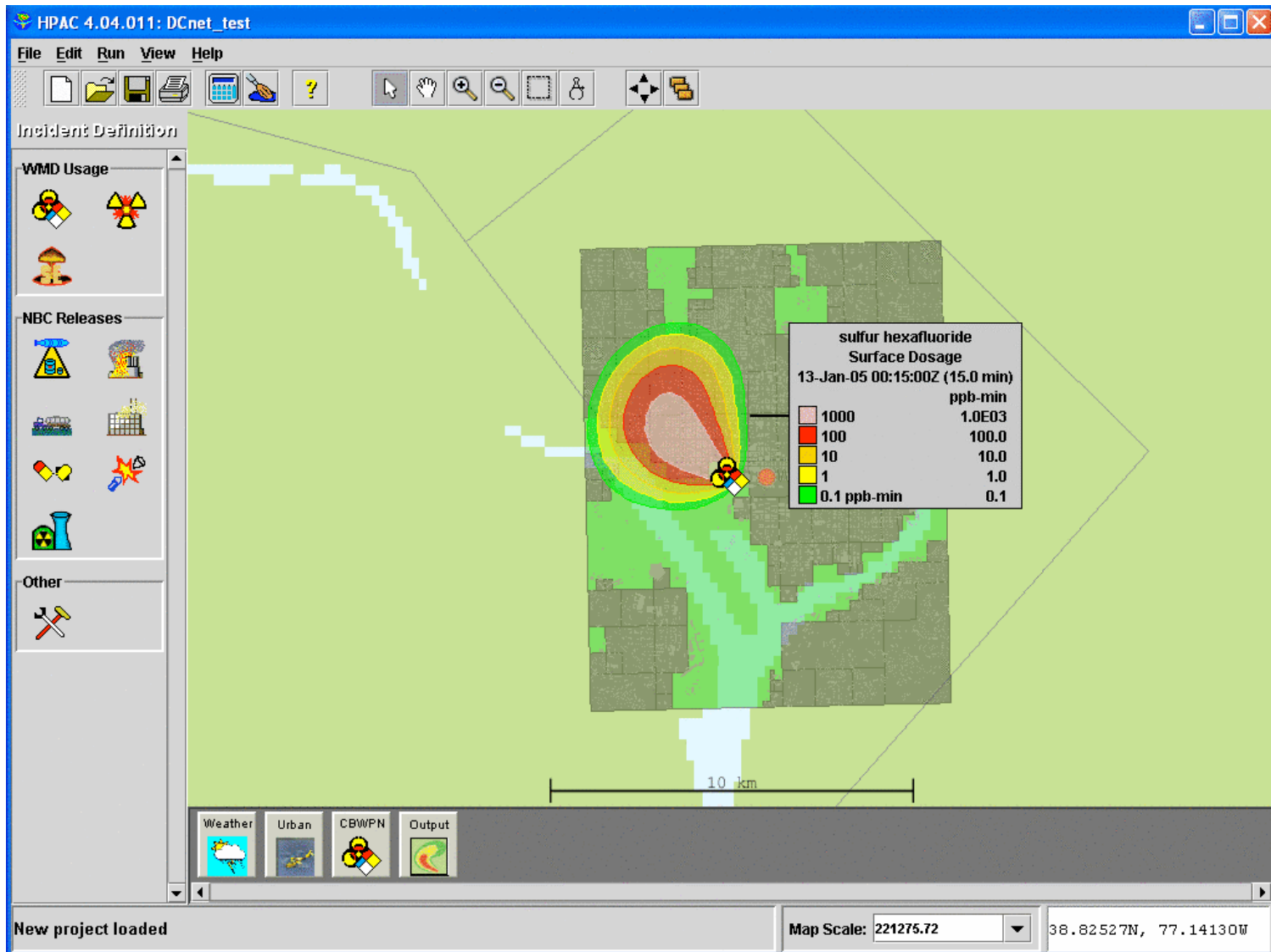
Step 6: Output Setup
HOURLY
postprocessing output:



HPAC GUI



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Requirements for stand-alone SCIPUFF



- Configuration files that describe
 - general information regarding calculation domain, simulation duration, time step, output frequency, source material properties
 - Description of meteorological data and surface characteristics
 - Source terms, location, release type, amount (or strength), duration



Meteorology Input



- One or more surface and/or upper-air observations
 - U, V (minimum required input)
 - Stability related variables (T, PGT, MOL)
 - Turbulence related variables (PBL height, sensible heat flux)
- Gridded model output from 4DWx systems
 - Height level, terrain, fixed lat/lon intervals
 - U, V, W, temperature
 - Terrain, PBL height, sensible heat flux
 - Uncertainty in U, V fields
 - Grid nesting capable



SCIPUFF Output



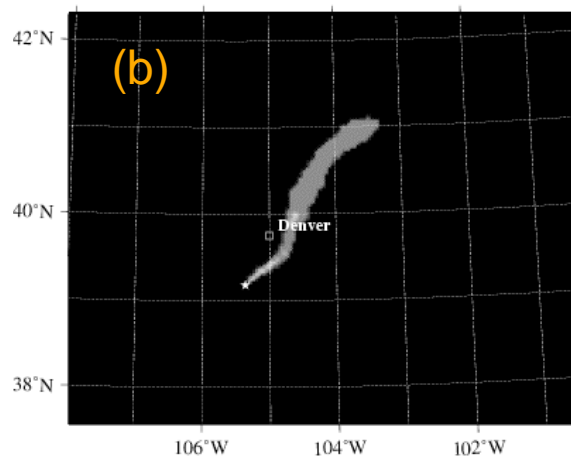
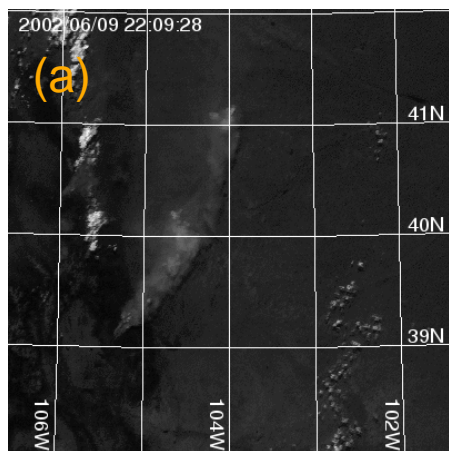
- Surface dosage file
- Surface deposition file
- Puff file, from which concentrations can be extracted
- Statistical quantities (mean and variance)



Coupled SCIPUFF Example 1



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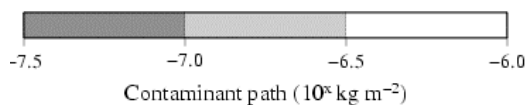
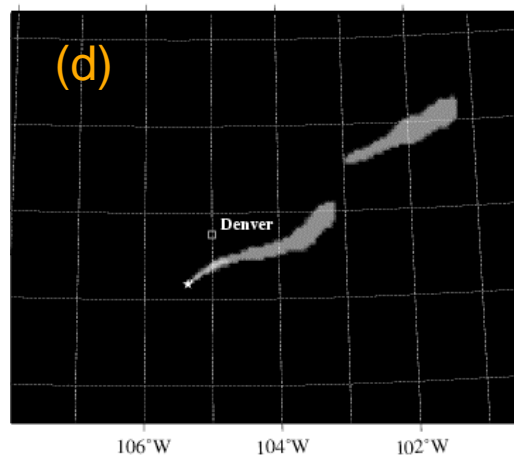
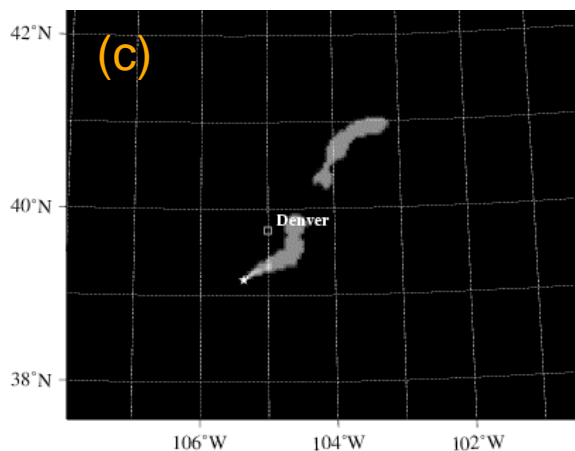
HAYMAN FIRE COLORADO

(a) Satellite visible imagery

(b) SCIPUFF coupled with
RTFDDA analysis

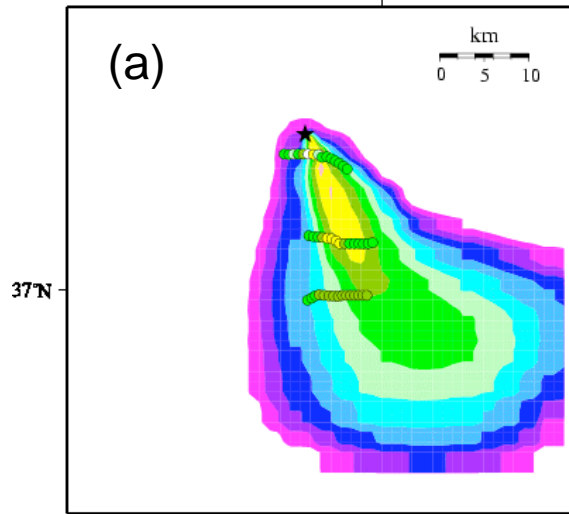
(c) SCIPUFF coupled with 6-
hour fcst

(d) SCIPUFF coupled with 12-
hour fcst





Coupled SCIPUFF Example 2



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Range scale

- (a) SCIPUFF driven by observations
- (b) SCIPUFF coupled with RTFD

