Short-range radionuclide dispersion and deposition modelling

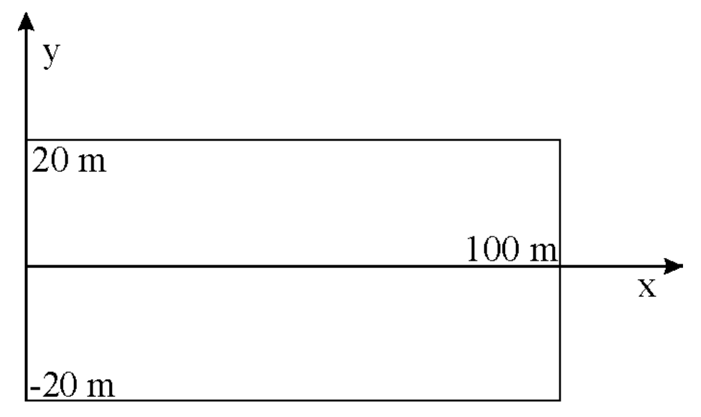
University of Seville model

EMRAS-2

Model characteristics

- Model specifically designed and developed for the exercise
- Lagrangian dispersion model: 10000 particles released
  - 5000 liquid particles
  - 5000 gas particles
- Each particle contains an amount of Bq depending on activity in explosive and on fractionation between liquid and gas
- The model does not try to reproduce the explosion itself, but dispersion just after it
- Differences between liquid and gas particles:
  - Initial conditions
  - Dispersion processes

Geometry of model domain



- Explosion site: origin of coordinates
- z axis directed upwards
- Results are provided on the rectangular box

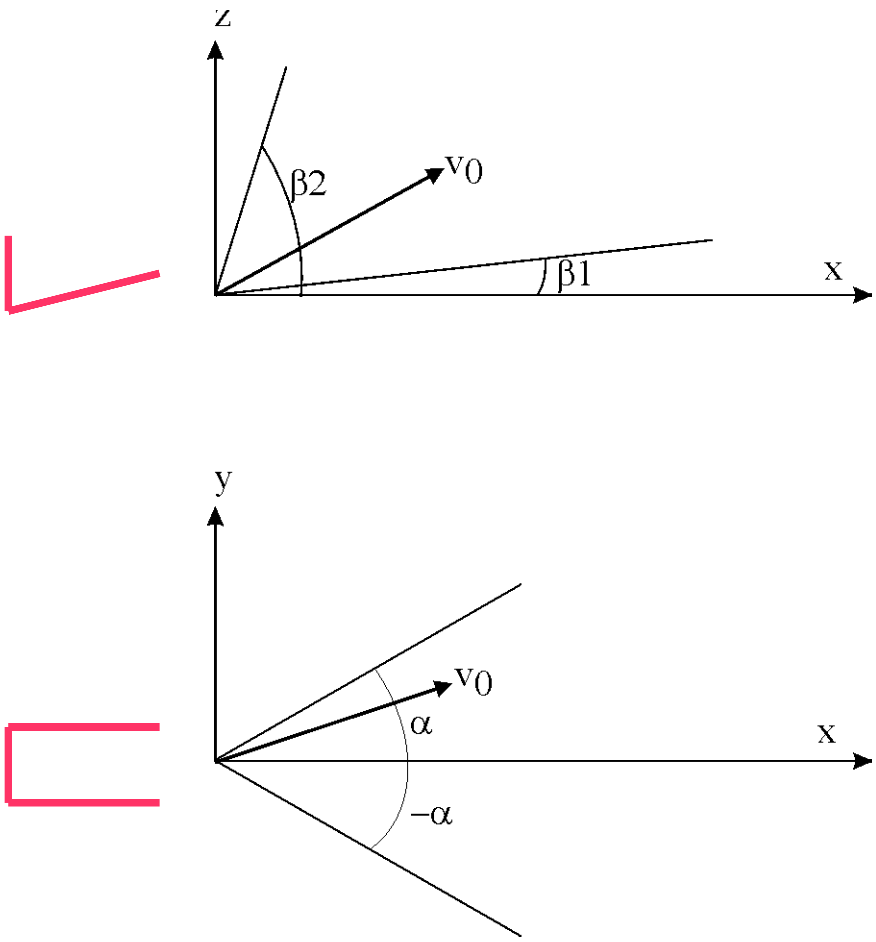
Liquid particles

- Dispersion processes:
  - Parabolic motion with air friction given an initial position and velocity of each particle
  - Advection with wind

- Initial position: anywhere within the explosive shielding (Monte Carlo method)

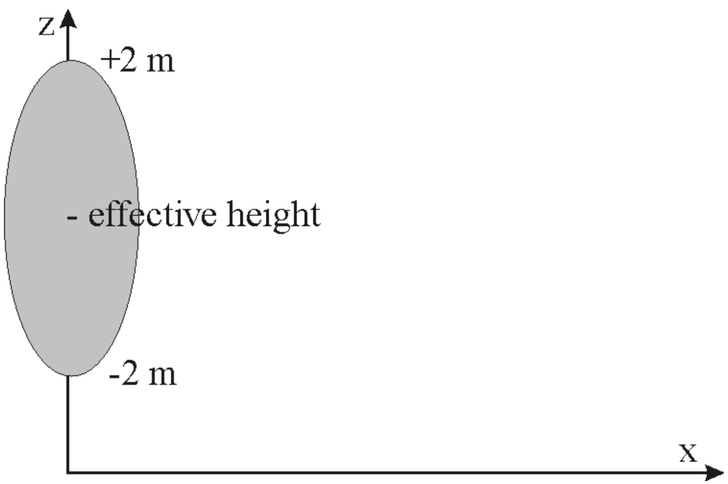
- Initial velocity:
  - A mean value v0 (m/s) and error (%) are introduced as input data
  - It is assumed that v0 magnitude obeys a normal distribution with the given mean value and standard deviation
  - The actual value for a given particle is obtained from a Monte Carlo method
  - The direction of v0 is limited by the explosive shielding (opened on one side and top):

Liquid particles



The actual direction is again obtained from a Monte Carlo method (all possible angles have the same probability)

Gas particles



•Initial positions: particles form a cloud over the explosion site at an effective height ± 2 m. The actual position for a given particle is obtained from a Monte Carlo method (all positions have the same probability)

•Dispersion:
- Advection by wind
- Turbulent diffusion (Monte Carlo method)

•Radioactive decay (liquid and gas particles): Monte Carlo method

Summary of model parameters

- Calibrated:
  - Initial velocity and error for liquid particles
  - Friction coefficient with air
  - Effective release height for gas particles
  - Fraction of activity released as aerosol (some indications are given in the scenario description)
- Standard values:
  - Turbulent diffusion coefficient in air
  - Radioactive decay constant
  - Dose conversion factor

Summary of model parameters

- From scenario:
  - Horizontal angle α
  - Vertical angles β1 and β2
  - Wind velocity components
  - Explosive shielding dimensions
  - Activity in explosive
  - Time from activity determination to explosion
- Simulation inputs:
  - Time step for model integration
  - Simulation time

Example of input file

```
input data for explosion code: test2
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12.,40.   initial particle velocity (m/s), tolerance (%)
40.       initial horizontal dispersion angle
30.,90.  vertical angles
0.93,0.   wind velocity components (m/s)
0.001     friction coefficient of liquid particles with air
30.       diffusion coefficient in air (m^2/s)
100       simulated time (sec)
.01       time step (s)
.80,.50   box explosive dimensions x,y (m)
1058.e6   total activity (Bq)
3.20e-5   radioactive decay constant (s-1)
80.       time in minutes from activity determination to explosion
```
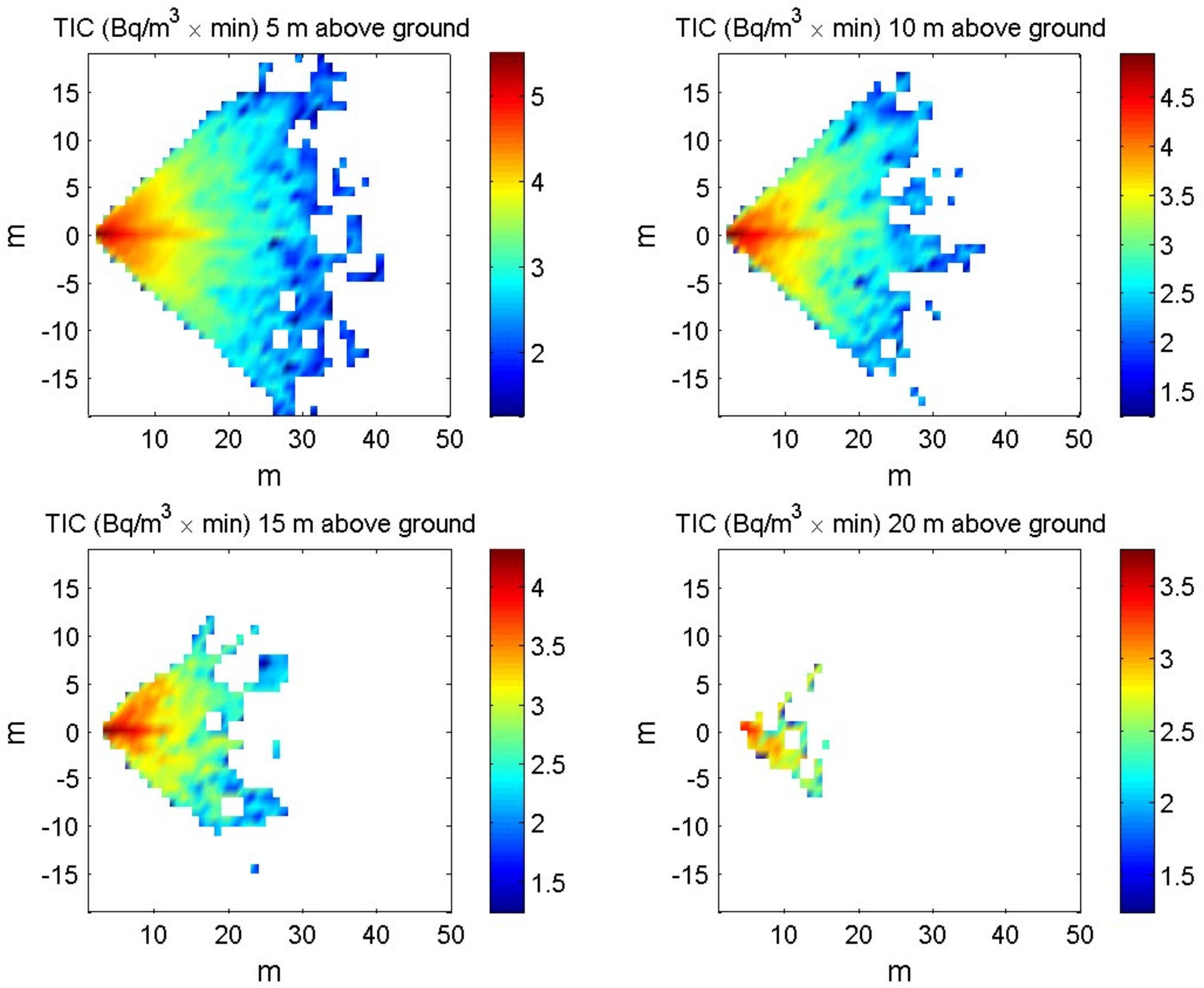

Model output

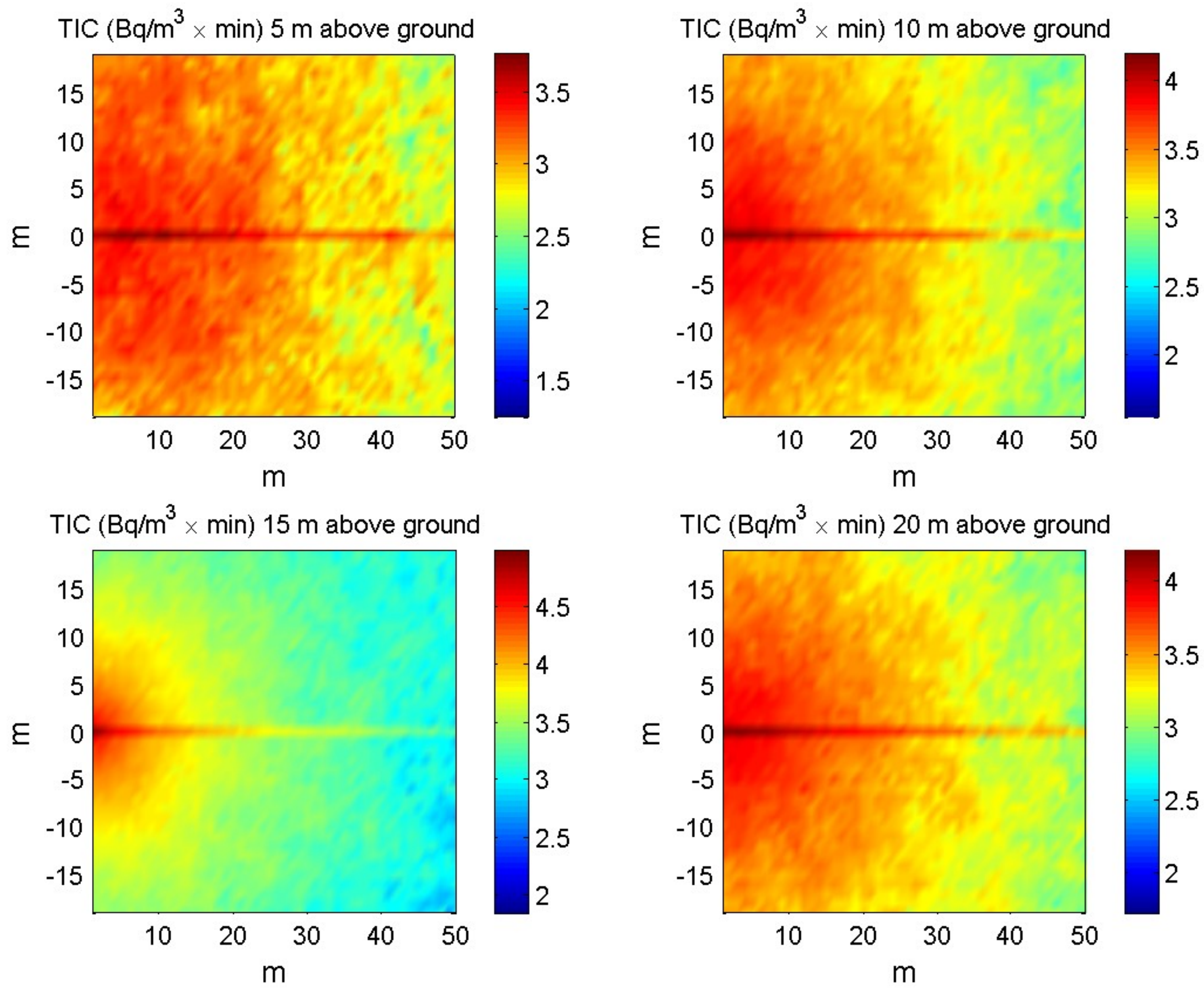
- Deposited activity on the ground on a 1×1 m grid
- Dose rates on the same grid (USEPA report EPA-402-R-93-081)
- Time integrated concentrations in air on the same grid and as function of height (1 m resolution) up to 30 m
- Requested results:
  - 50, 75 and 95 percentiles of total deposited activity (radius of a circle containing such fraction)
  - Surface contamination and dose rates on a 5×5 m grid
  - Time integrated air concentrations along centerline over 5 m intervals and as a function of height

100% of activity in liquid particles



Log10 scales

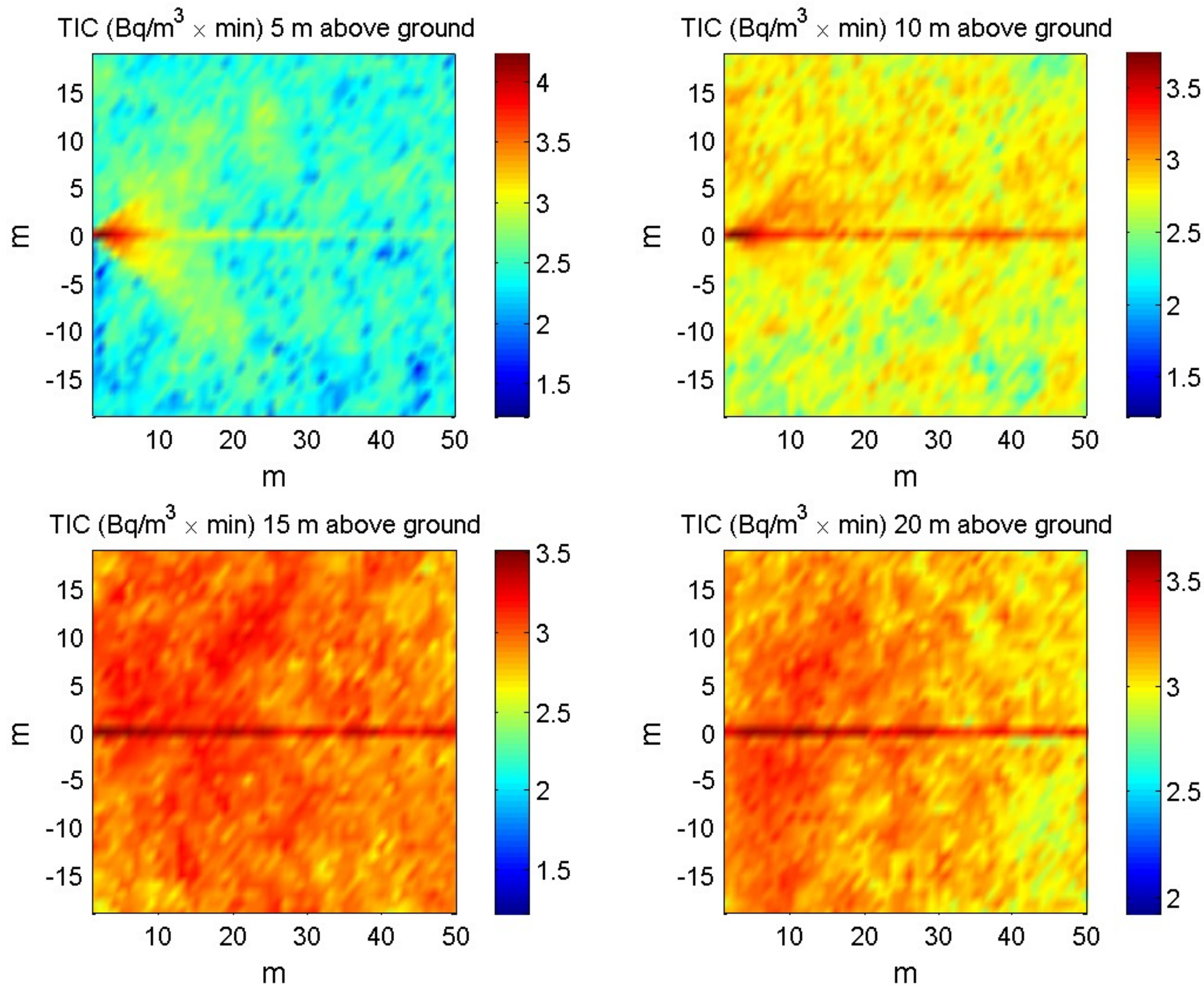
100% of activity in aerosol fraction



Effective release height: 15 m

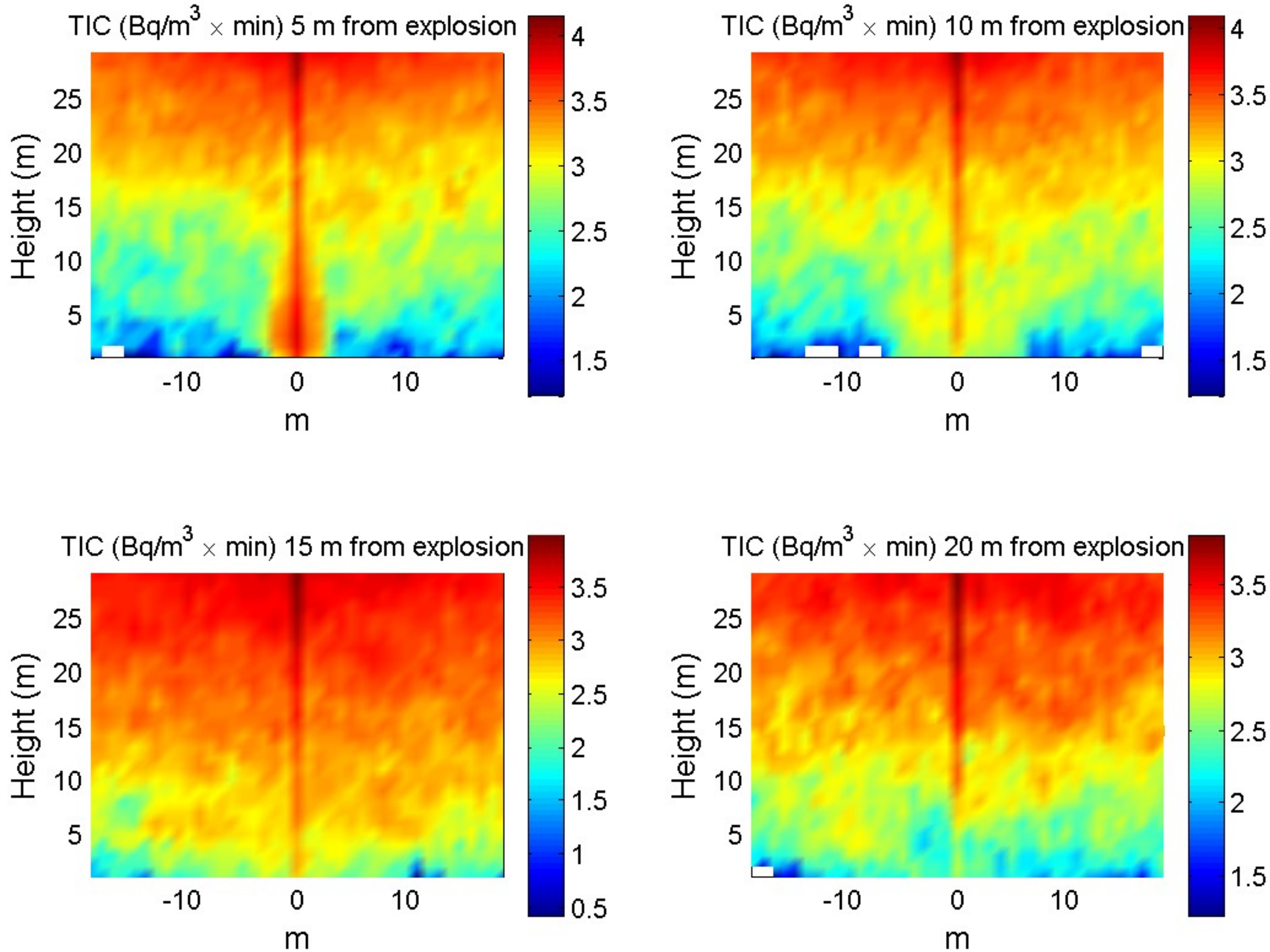
Log10 scales

Test 2 results



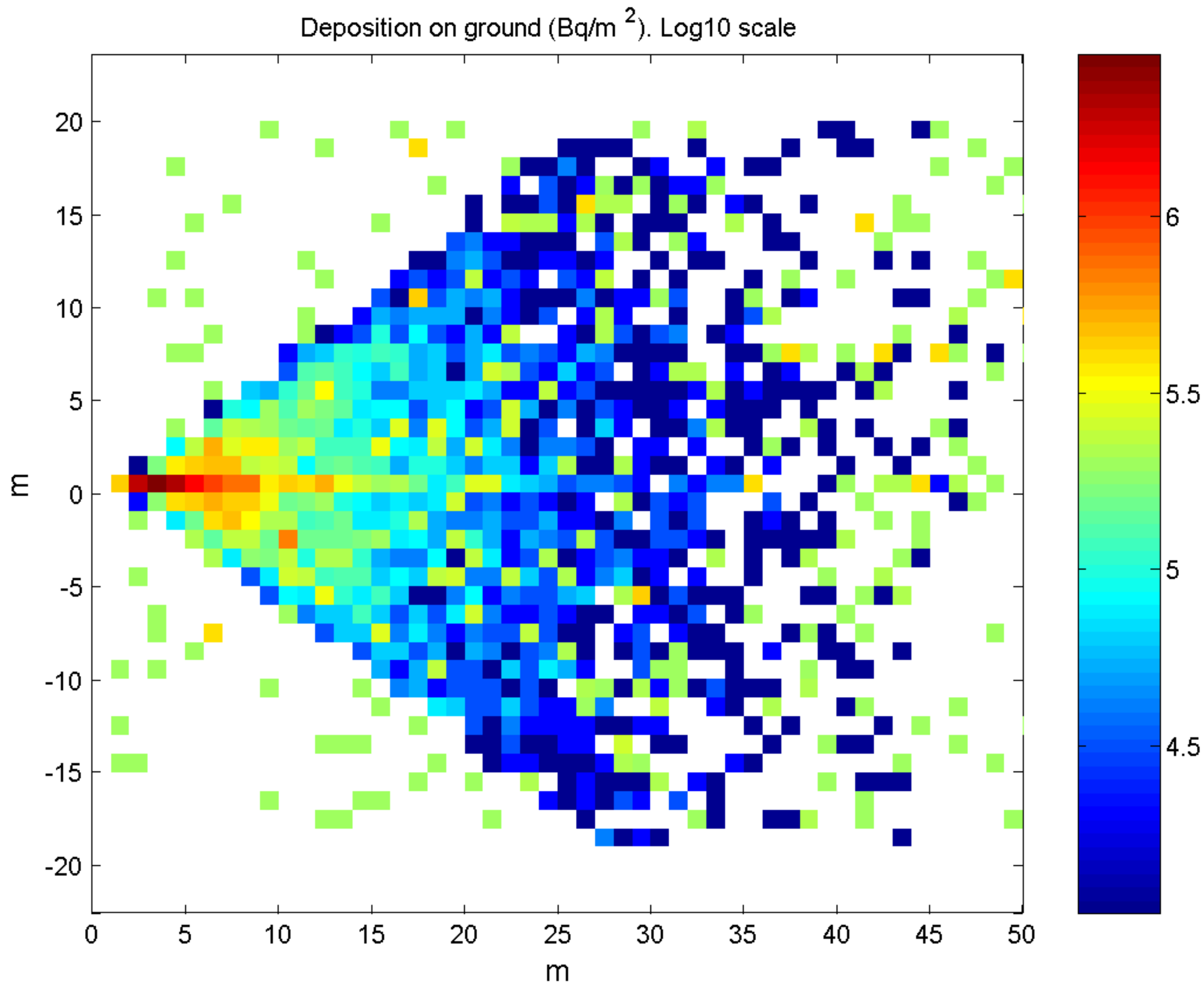
Log10 scales

Test 2 results

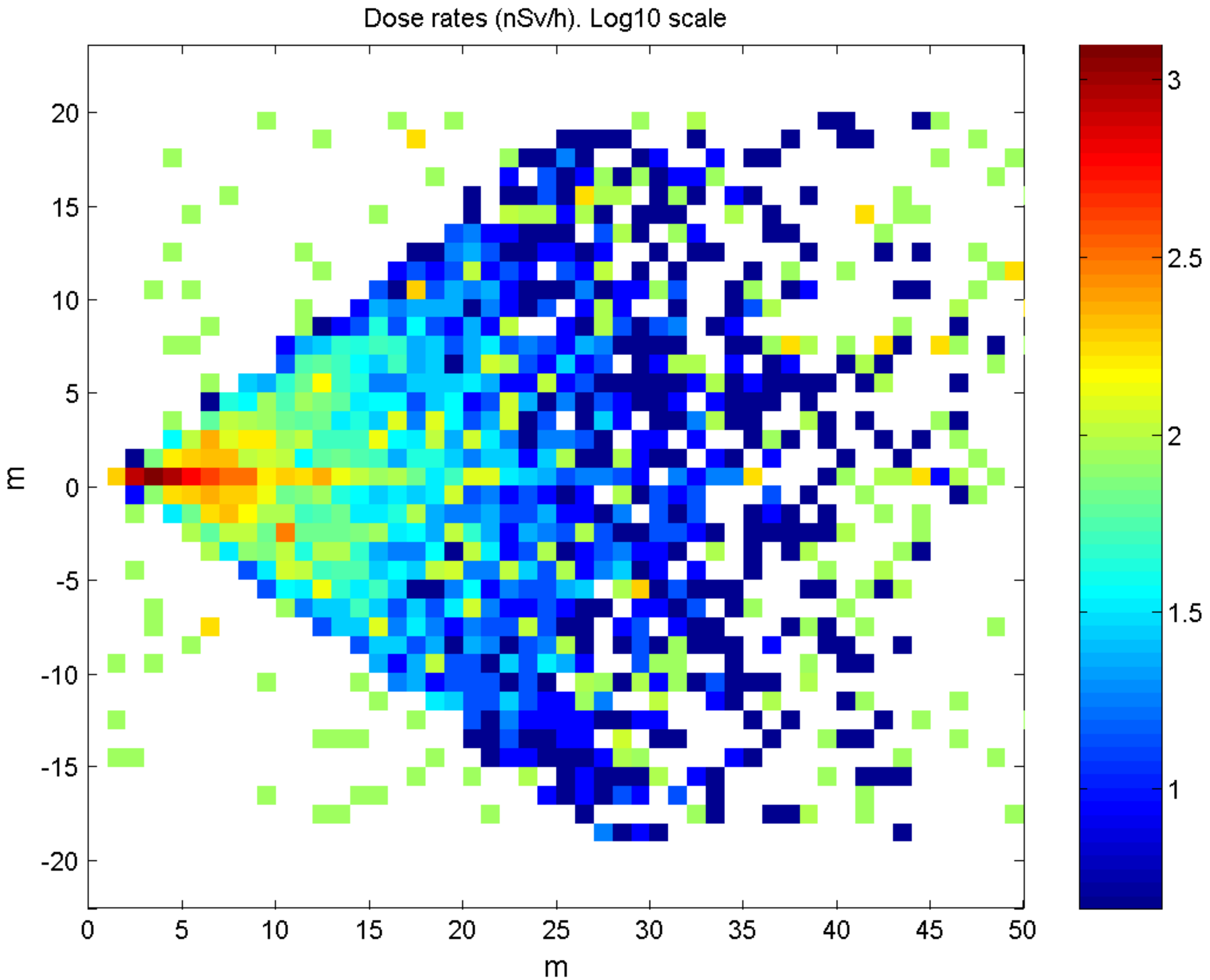


Log10 scales

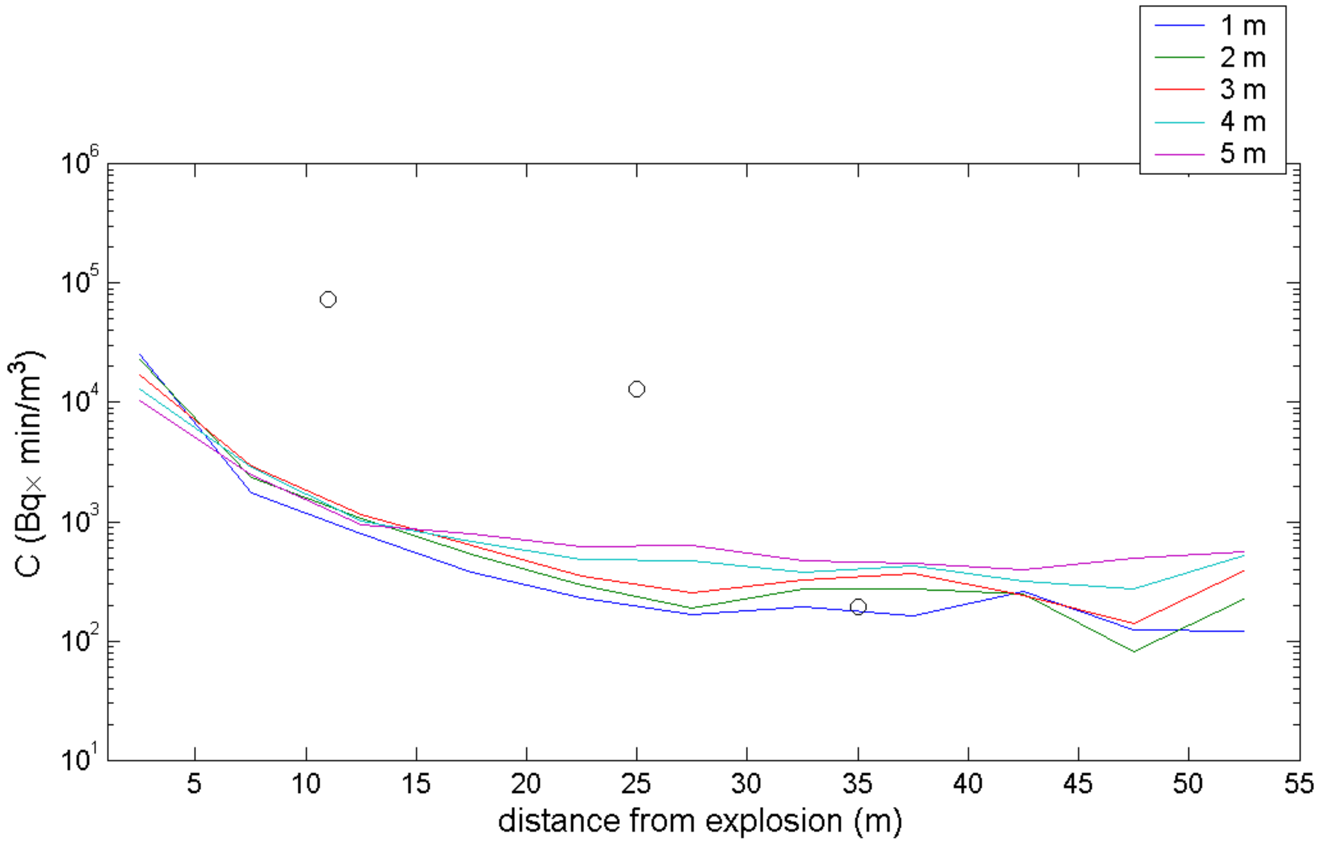
Test 2 results



Test 2 results



Test 2 results



Time integrated air concentrations along centerline over 5 m intervals