Short-range radionuclide dispersion and deposition modelling

Vienna, January 2011

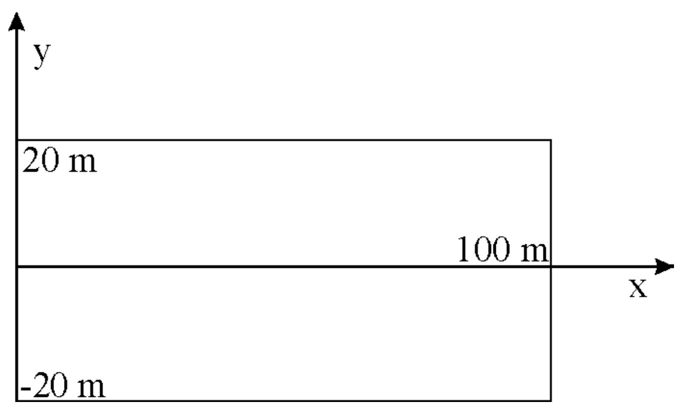
University of Seville model

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

Extended model domain to 2000 m downstream and 100 m upstream

Liquid particles

- Dispersion processes:

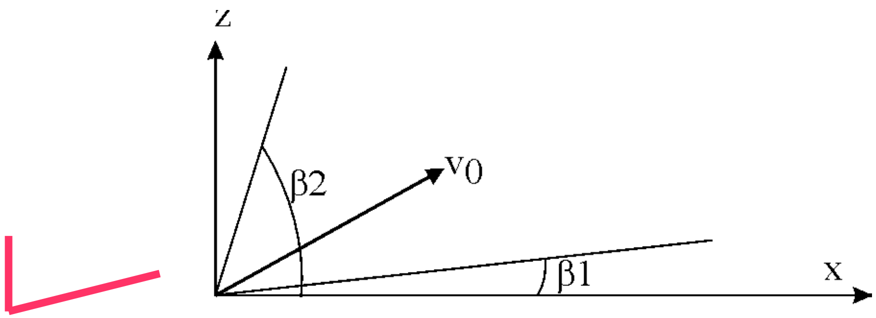
  -Parabolic motion with air friction given an initial position and velocity of each particle
  -Advection with wind (variable winds)
  -Vertical wind profile (logarithmic)

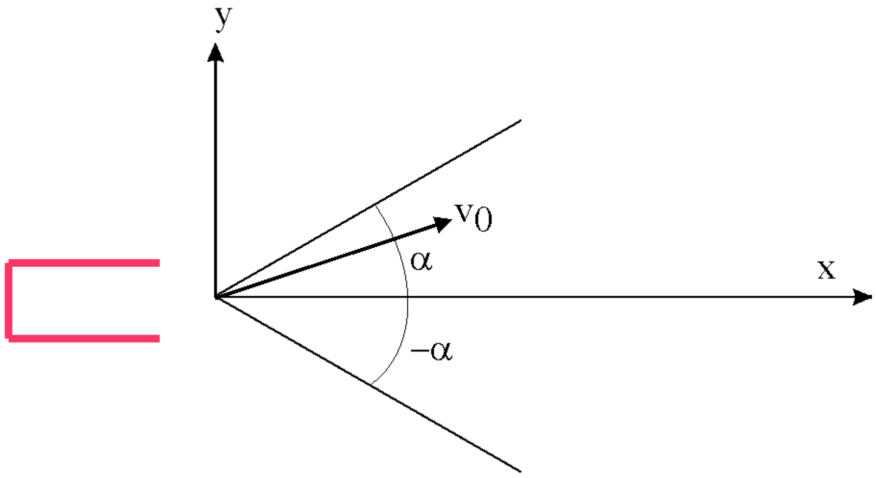
•Initial position: anywhere within the explosive shielding (Monte Carlo method)

•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. Two formulations have been used:

- particles form a 7×7 m^2 cloud over the explosion site at an effective height ± 6 m. The actual position for a given particle is obtained from a Monte Carlo method (all positions have the same probability)
- Cloud top formulation as HotSPOT model.

•Dispersion:

Advection by wind (variable wind and vertical wind profile)

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/cloud top

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

Obstacle positions

Simulation inputs:

Time step for model integration

Simulation time

Example of input file

```
input data for explosion code: test2
------------------------------------
12.,40.      initial particle velocity (m/s), tolerance (%)
40.          initial horizontal dispersion angle
30.,90.      vertical angles
0.001        friction coefficient of liquid particles with air
30.          diffusion coefficient in air (m^2/s)
15           simulated time (min)
.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
.95          fraction of activity in aerosol
34.8         effective mean release height for aerosol particles/CT (m)
7.0          cloud radius
```

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:

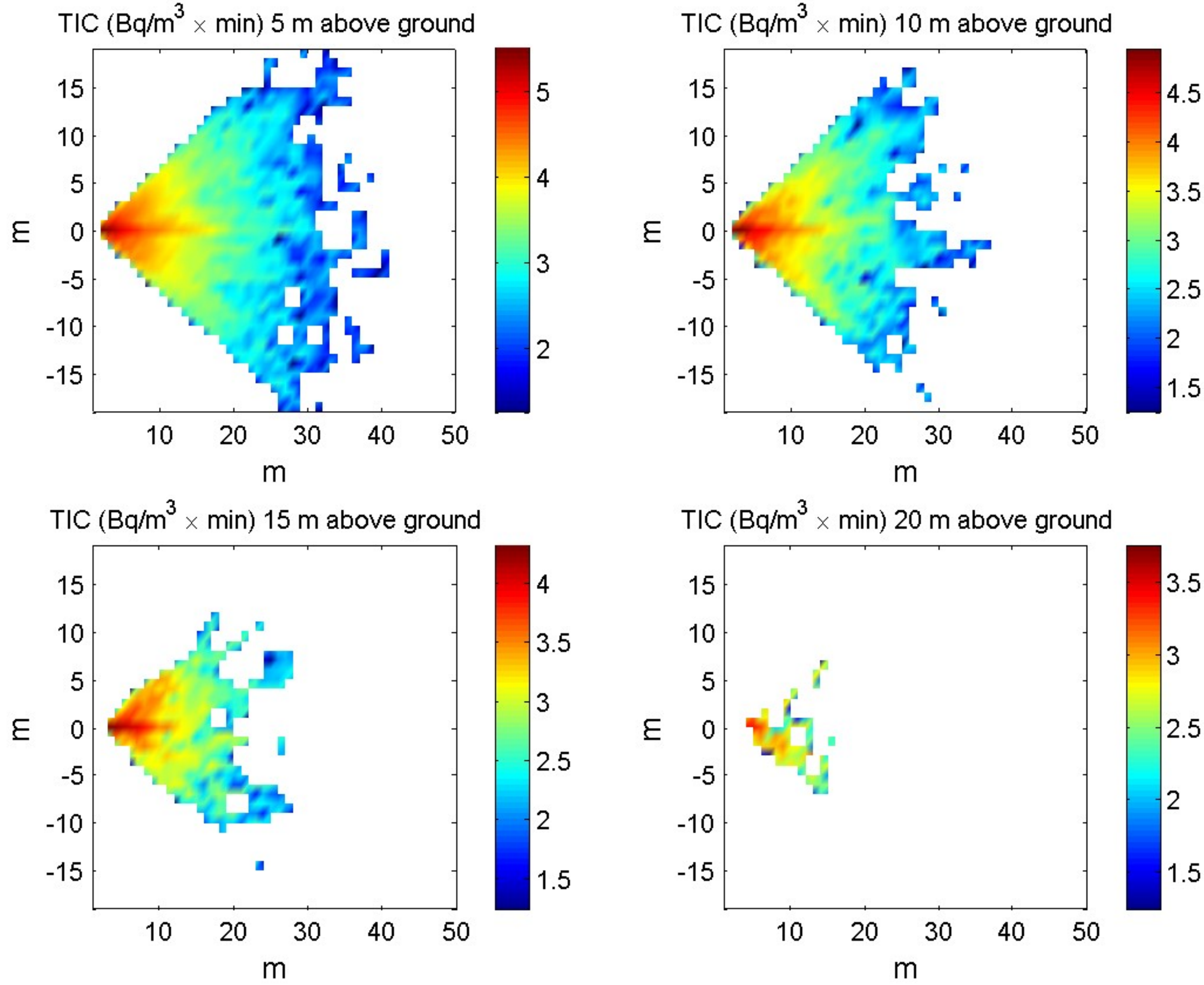
50, 75 and 95 percentiles of total deposited activity (radius of a circle containing such fraction)

Surface contamination and dose rates on a 5×5 m grid

Surface contamination and dose rates on a 25×25 m grid

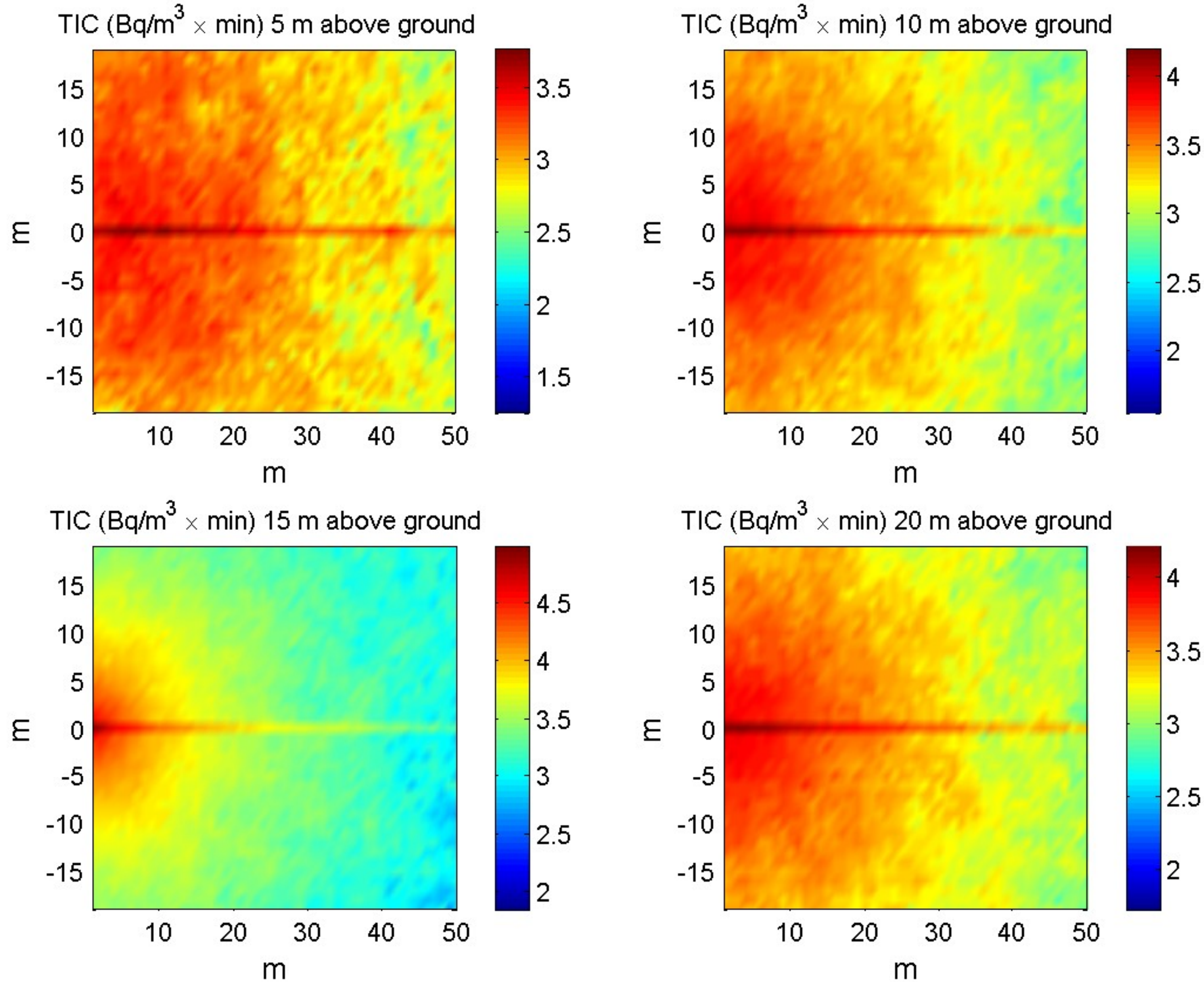
Time integrated air concentrations on 5×5 and 25×25 m grids 15 min after explosion at heights 5, 10 and 15 m.

100% of activity in liquid particles



Log10 scales

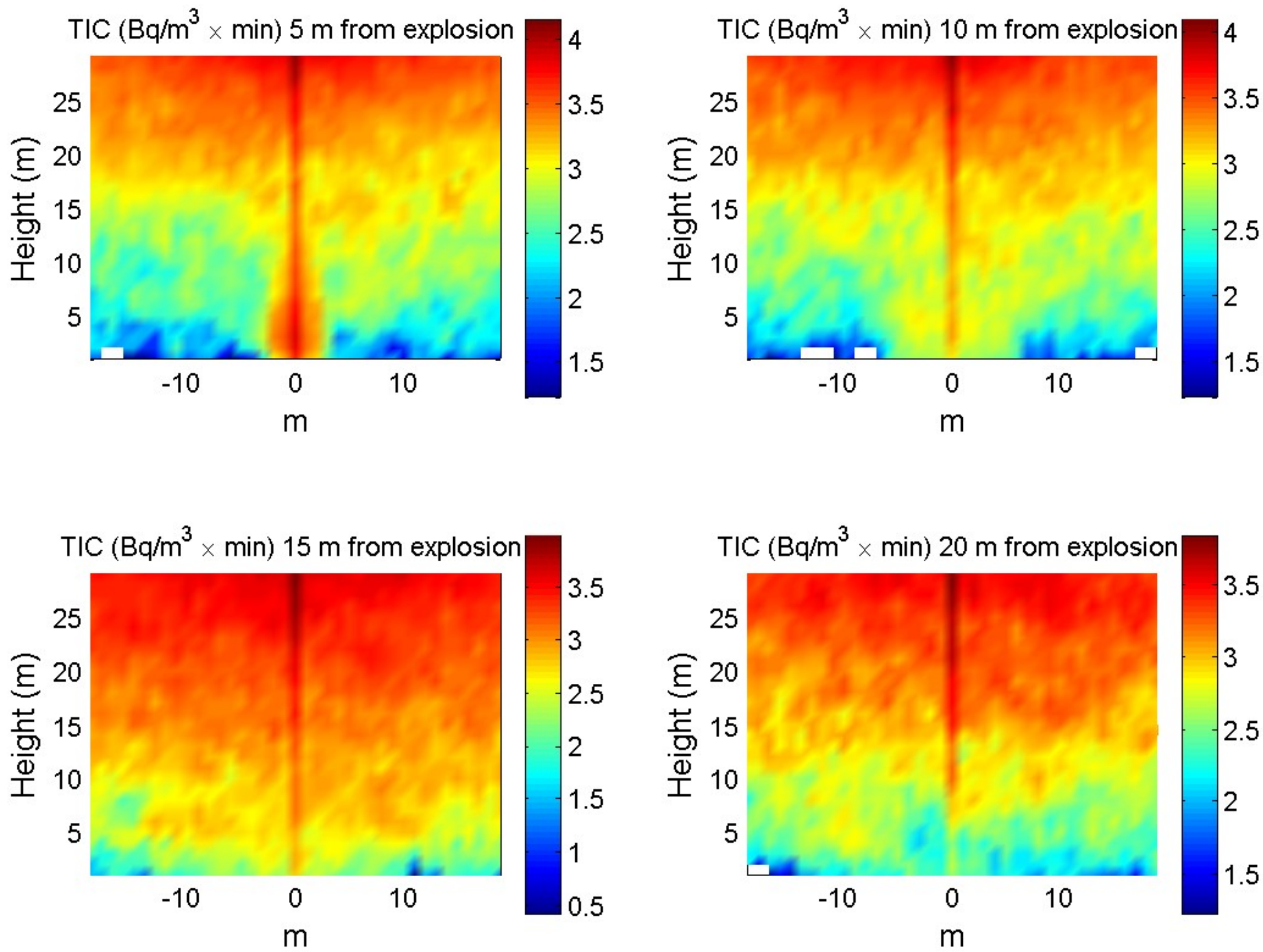
100% of activity in aerosol fraction



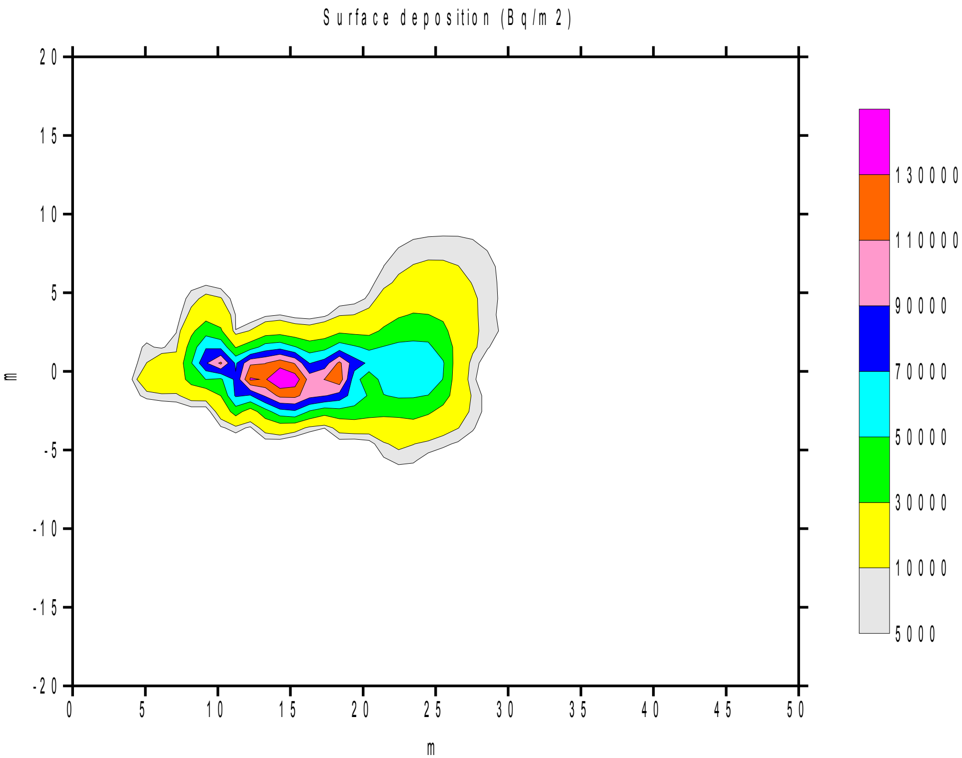
Effective release height: 15 m

Log10 scales

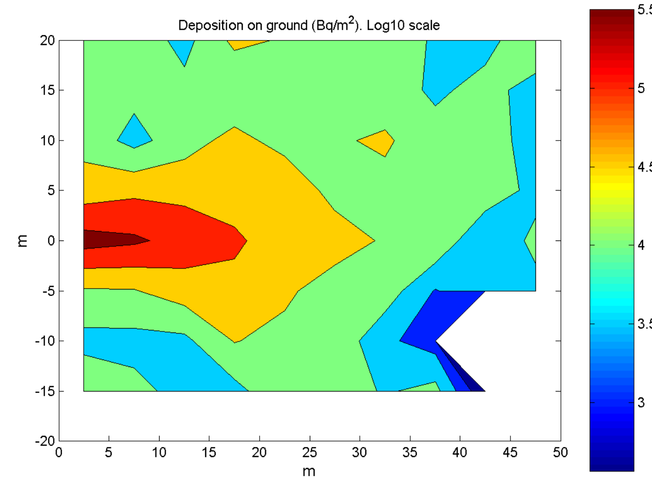
Vertical sections of TIC



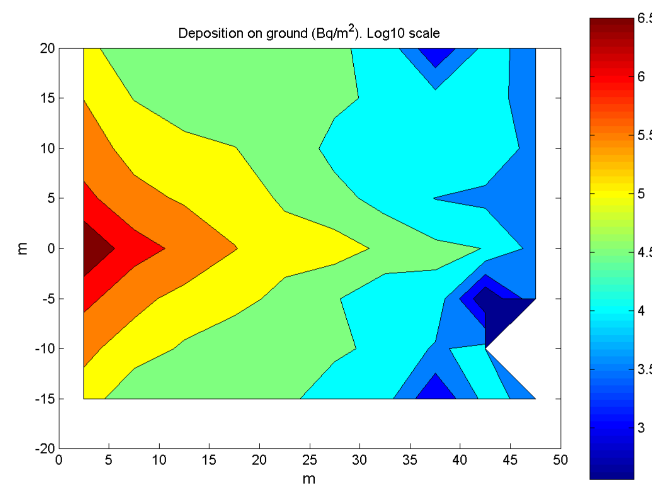
Test 2: surface deposition



From measurements

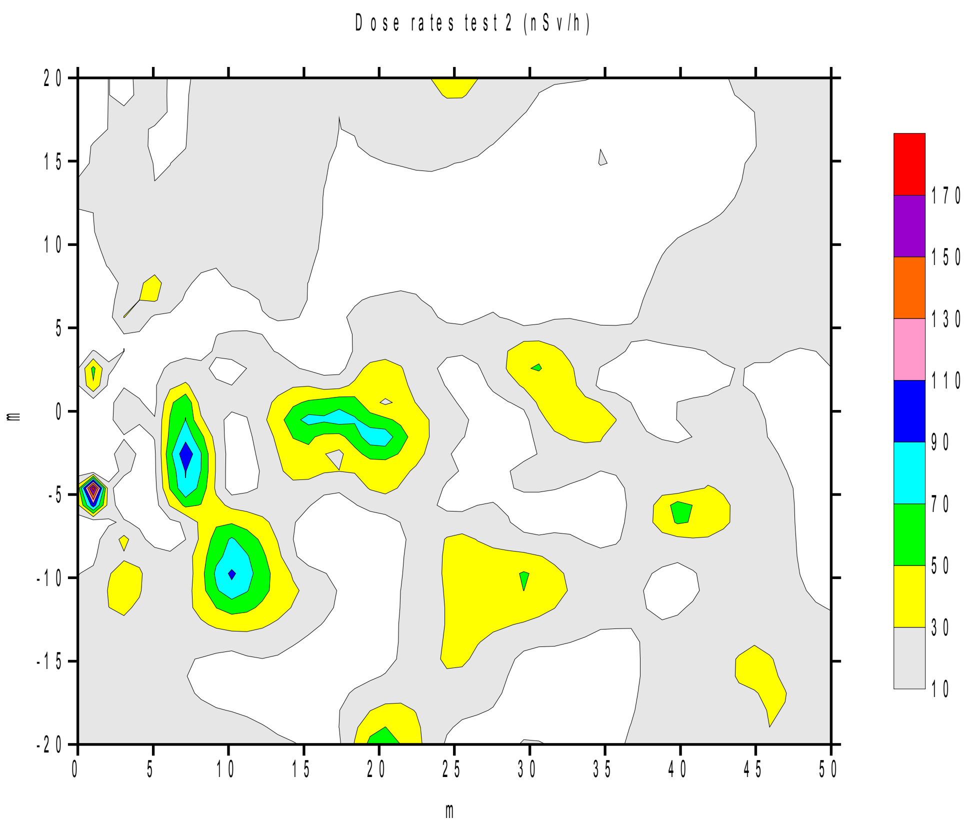


Effective release height

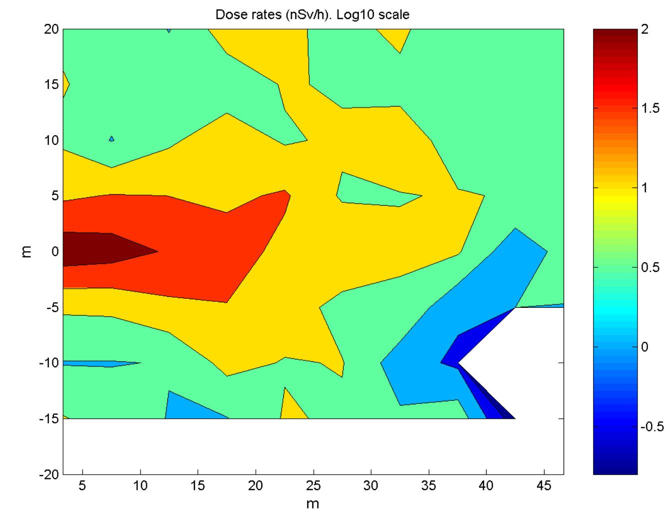


Cloud top formulation

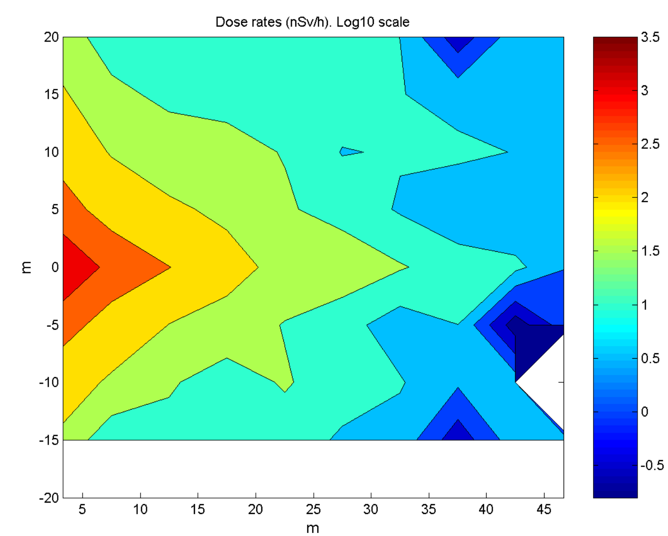
Test 2: dose rates



From measurements

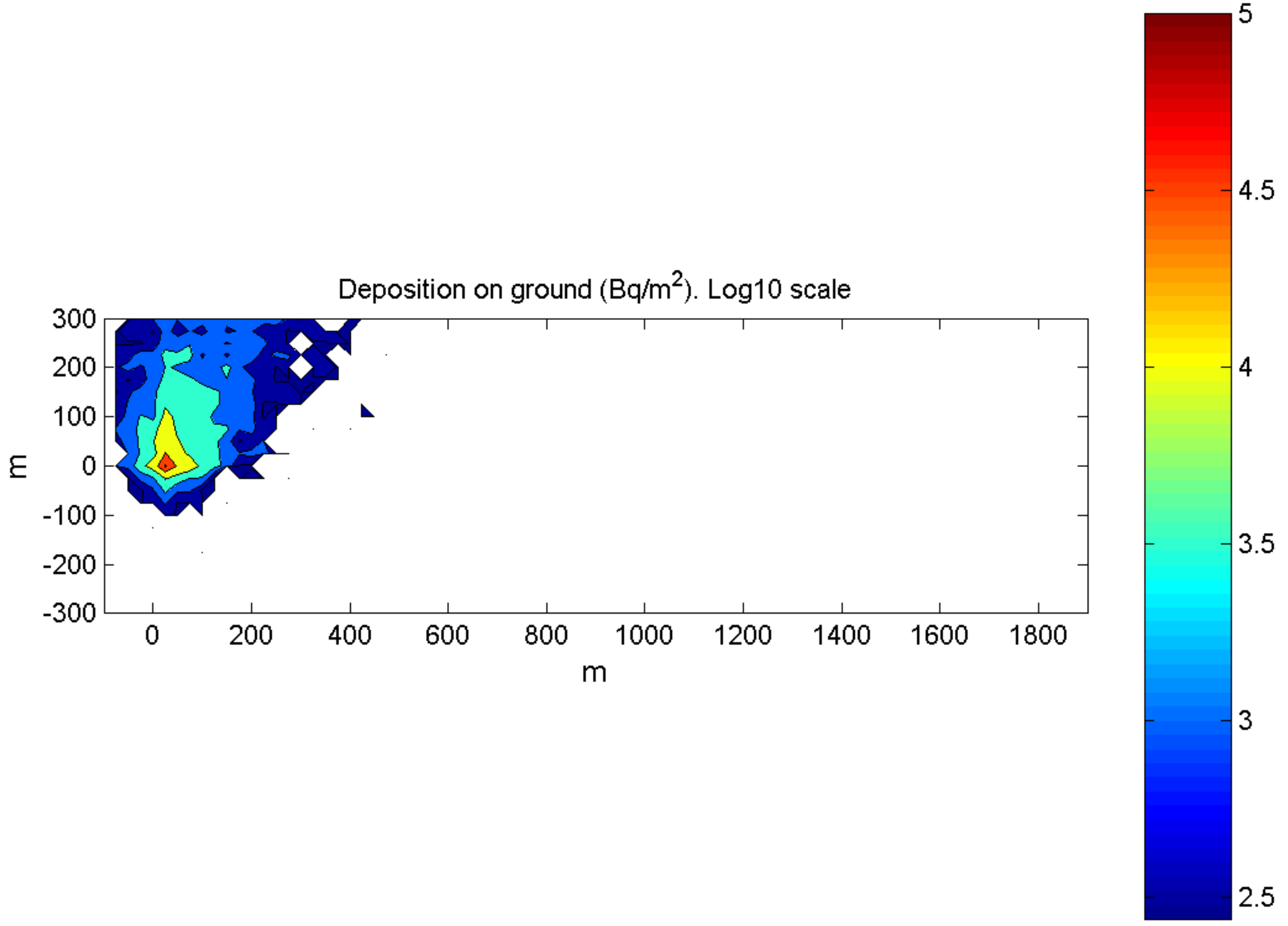


Effective release height

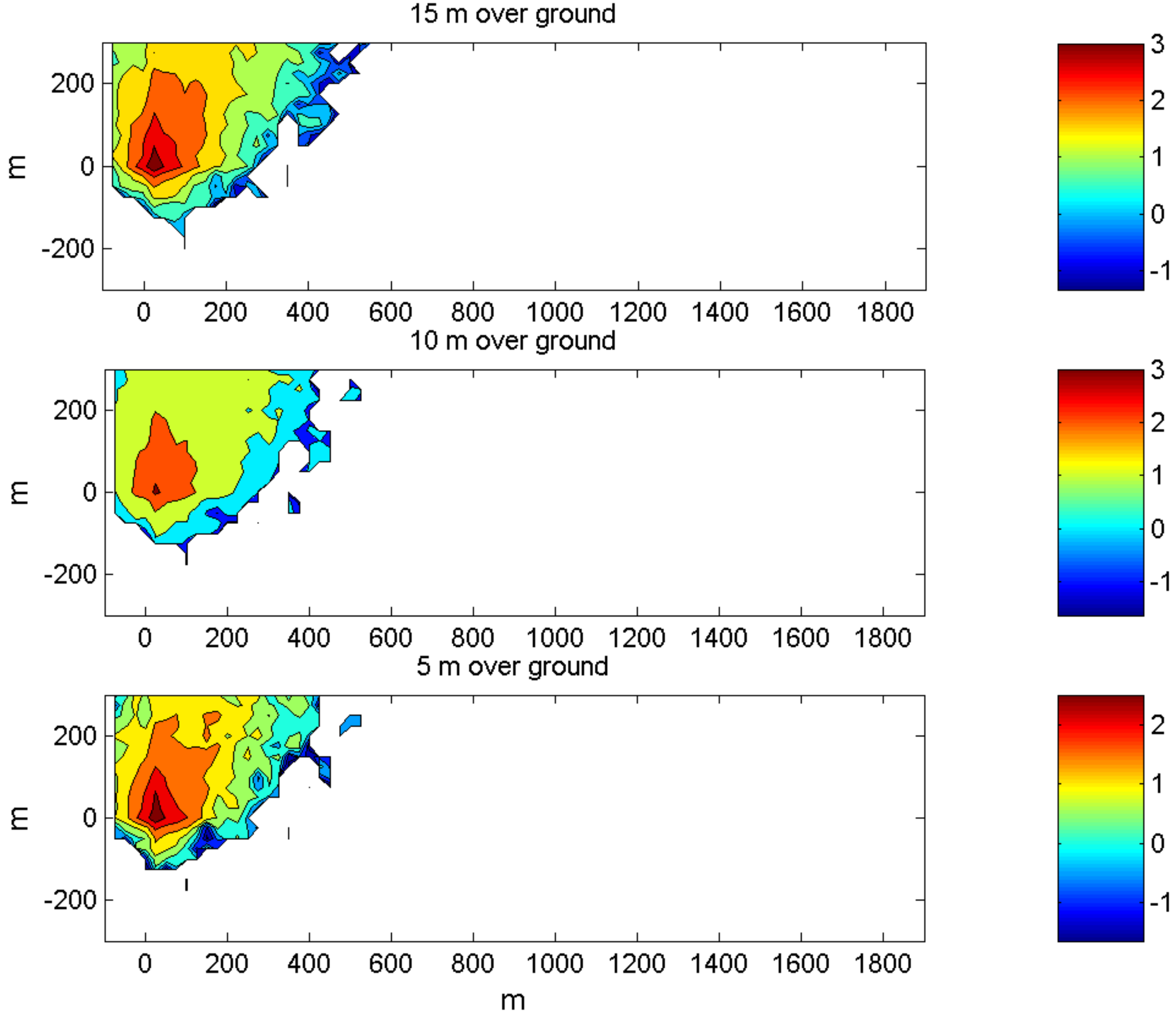


Cloud top formulation

Test 2: ground deposition, 25 m grid

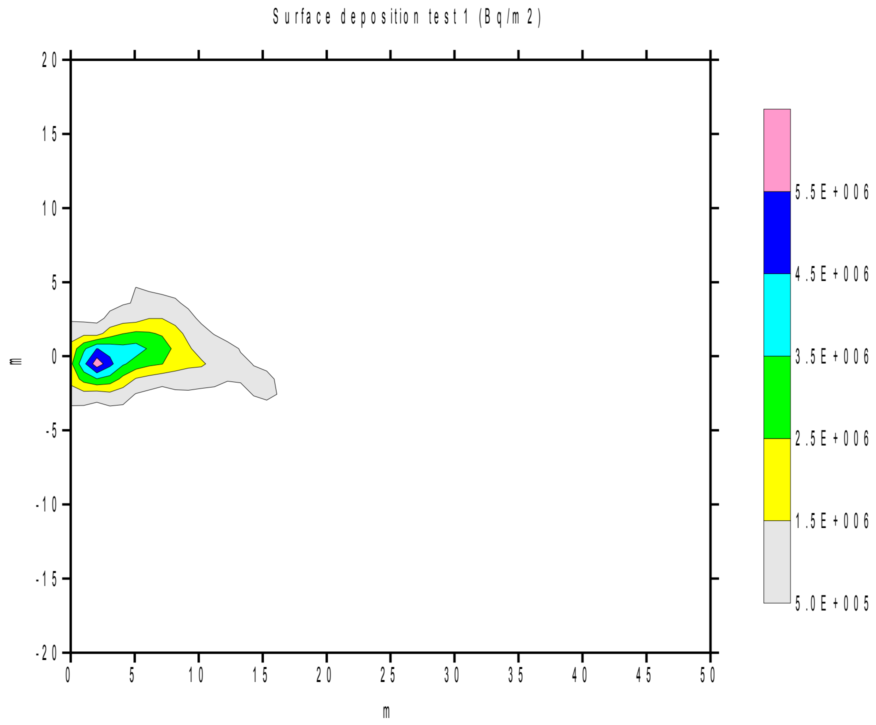


Test 2: TIC in air, 15 min after explosion

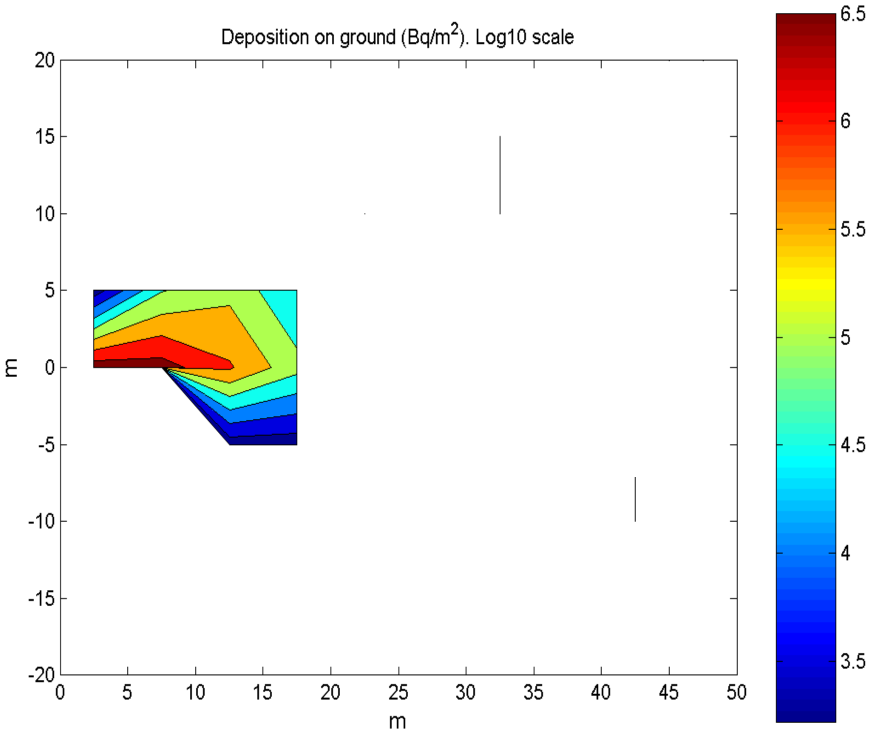


Bq/m^3×min
Log scale

Test 1: surface deposition

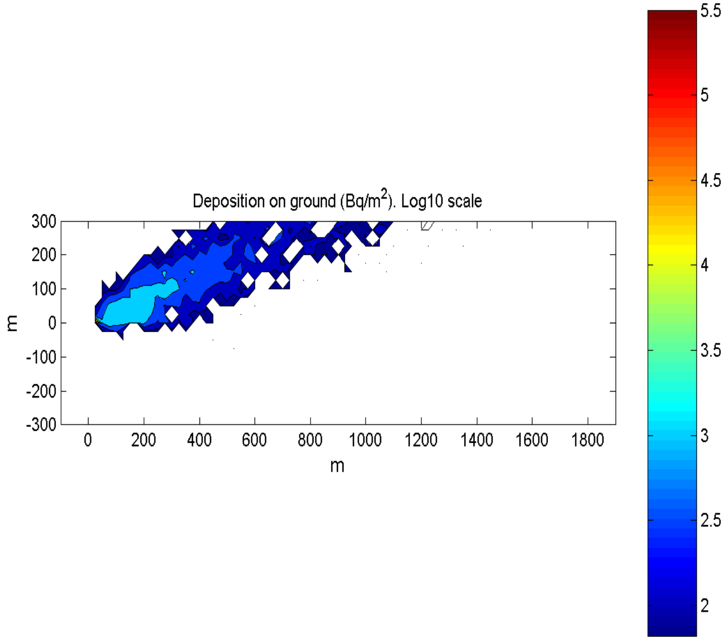


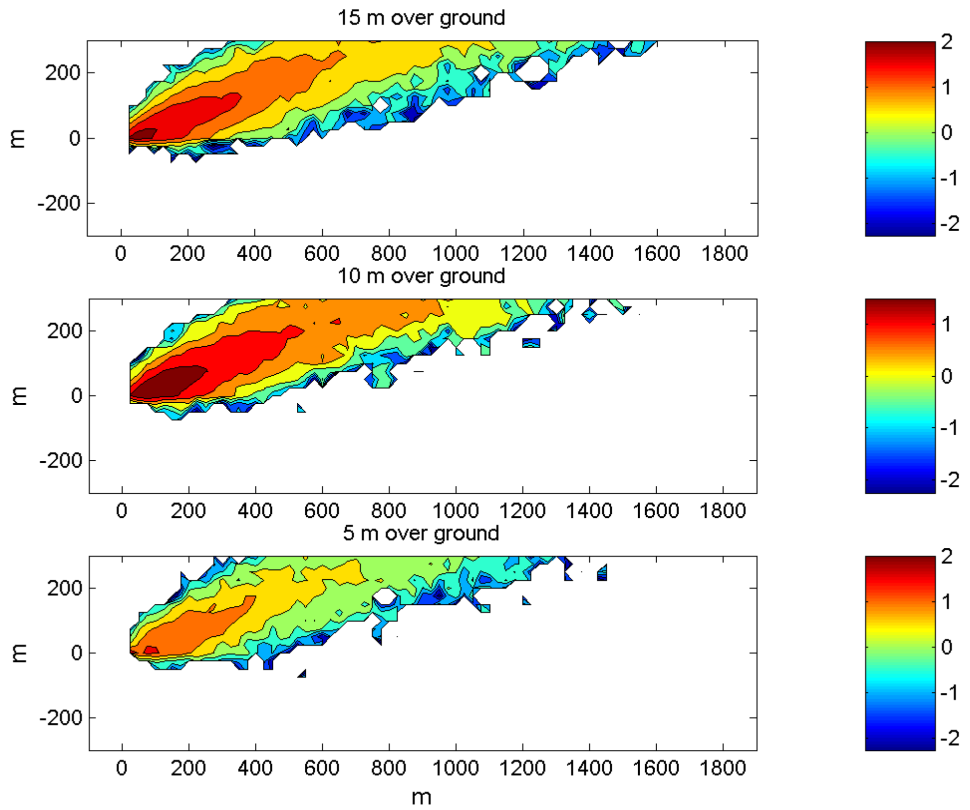
Measured



Model

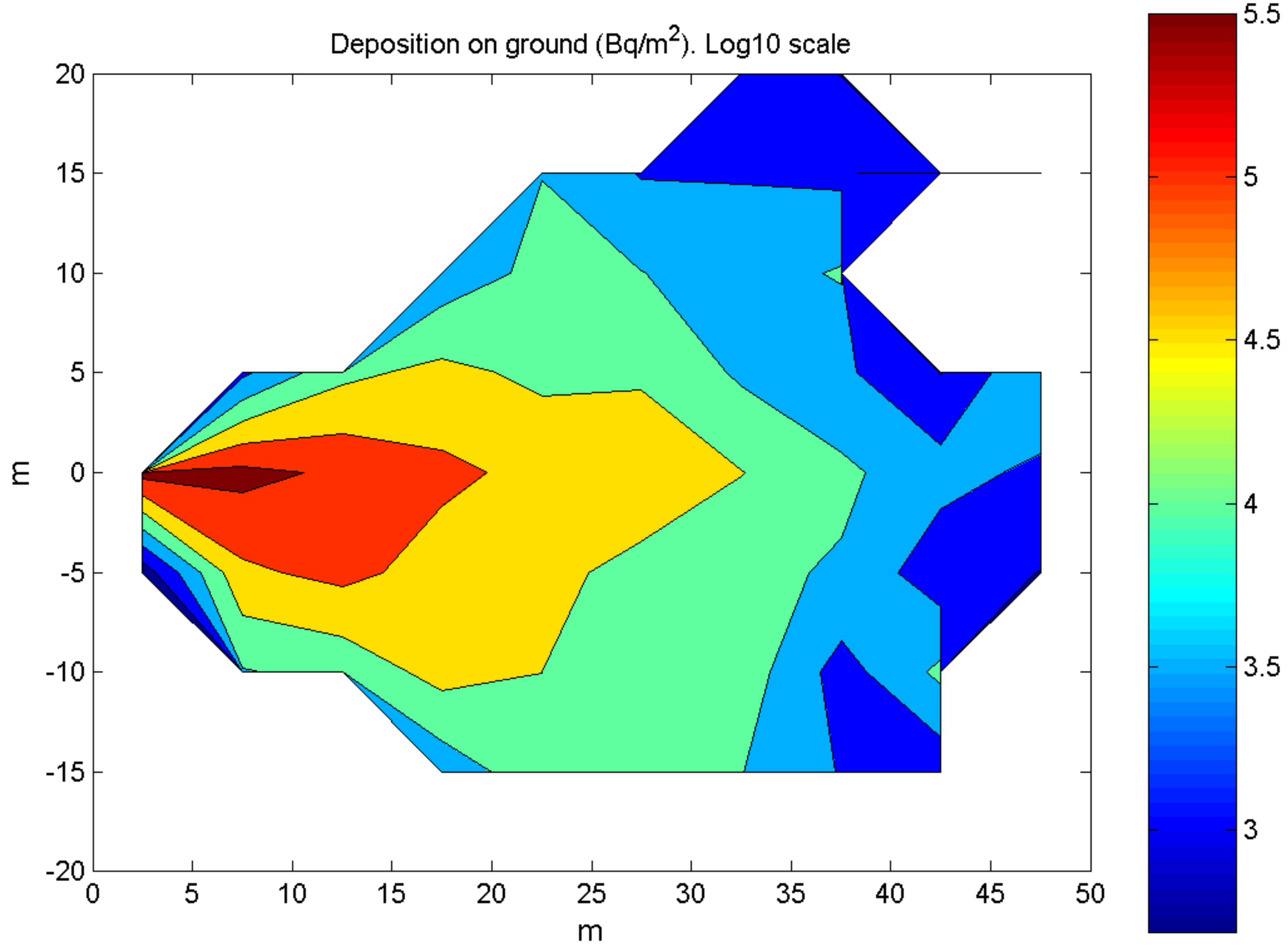
Test 1





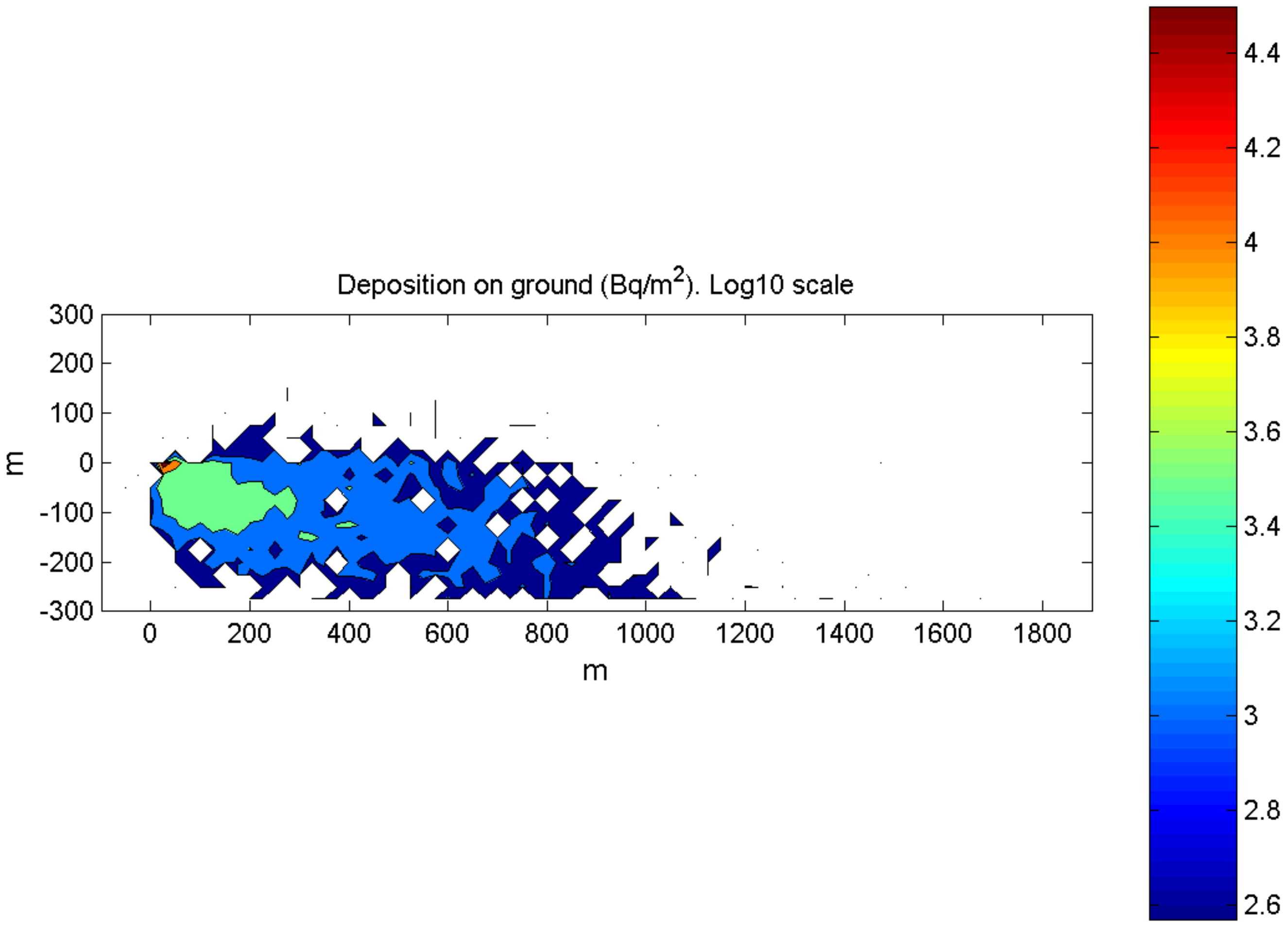
TIC in air, 15 min after explosion (Bq/m^3×min). Log scale

Test 3



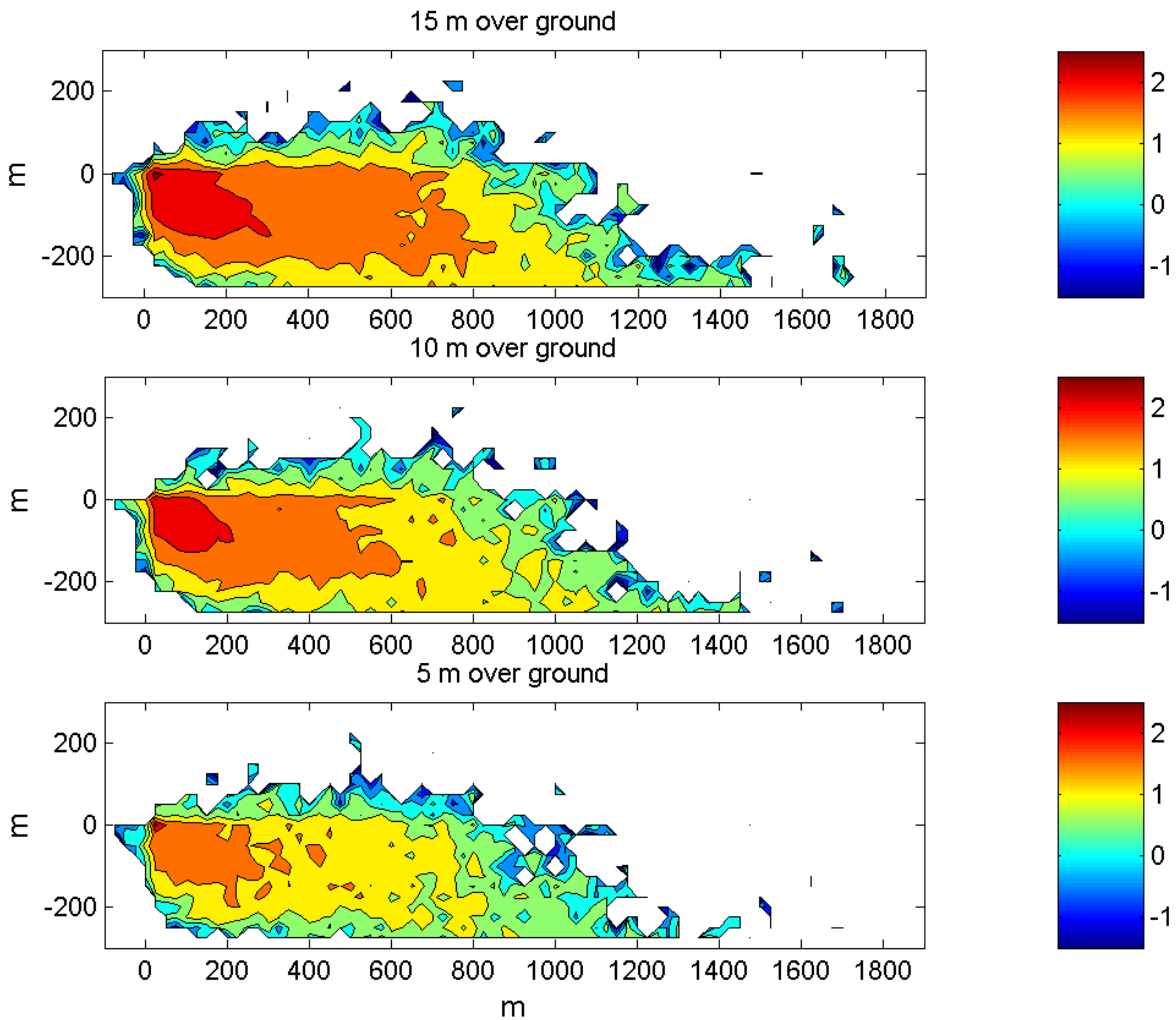
Deposition on ground (Bq/m2). Log10 scale
20
15
10
5
0
-5
-10
-15
-20
m
0
5
10
15
20
25
30
35
40
45
50
m
5.5
5
4.5
4
3.5
3

Test 3



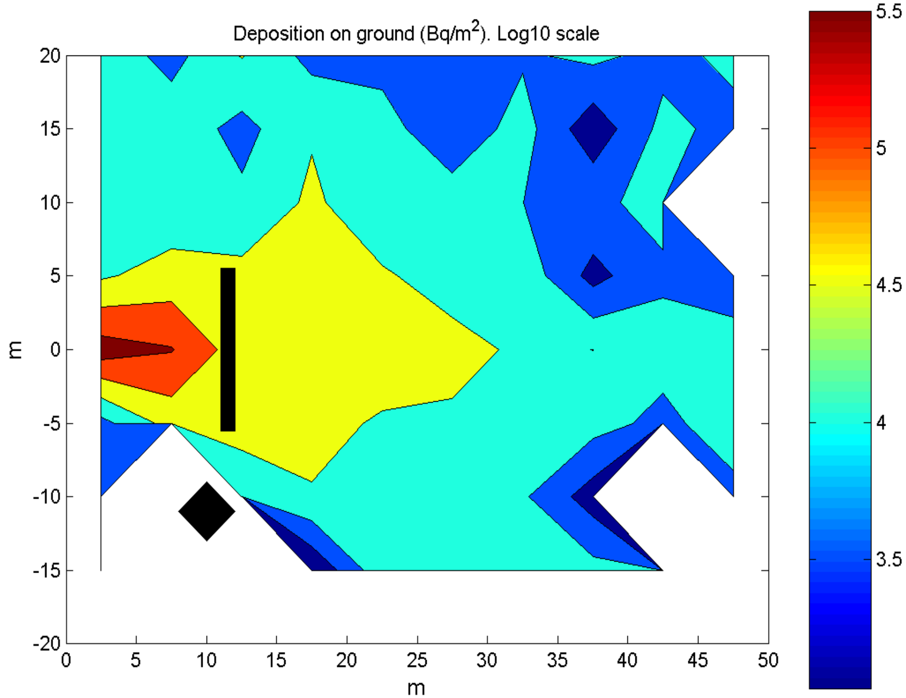
Deposition on ground (Bq/m^2). Log10 scale
300
200
100
0
-100
-200
-300
m
0
200
400
600
800
1000
1200
1400
1600
1800
m
4.4
4.2
4
3.8
3.6
3.4
3.2
3
2.8
2.6

Test 3

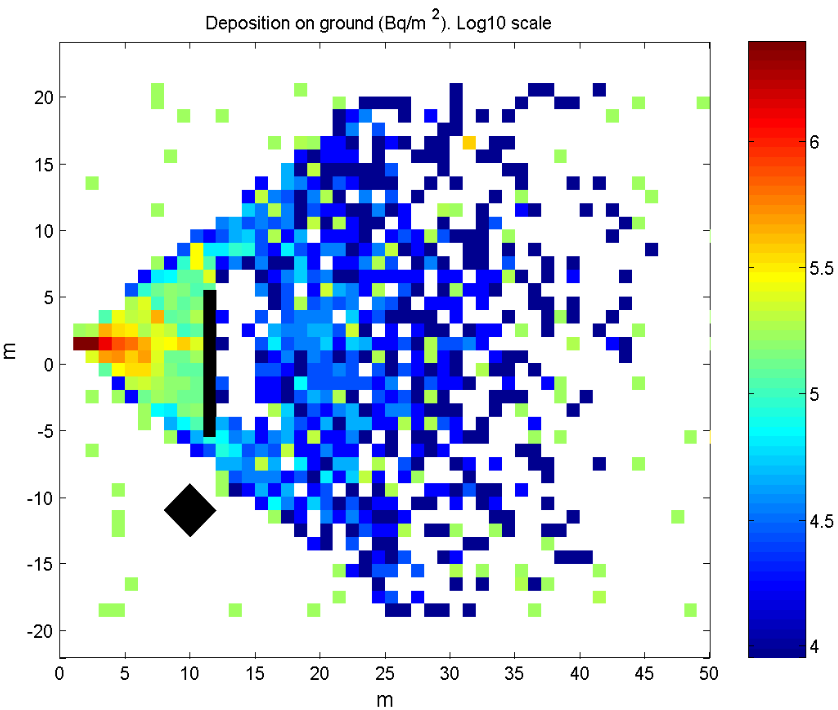


TIC in air, 15 min after explosion (Bq/m^3×min). Log scale

Test 4

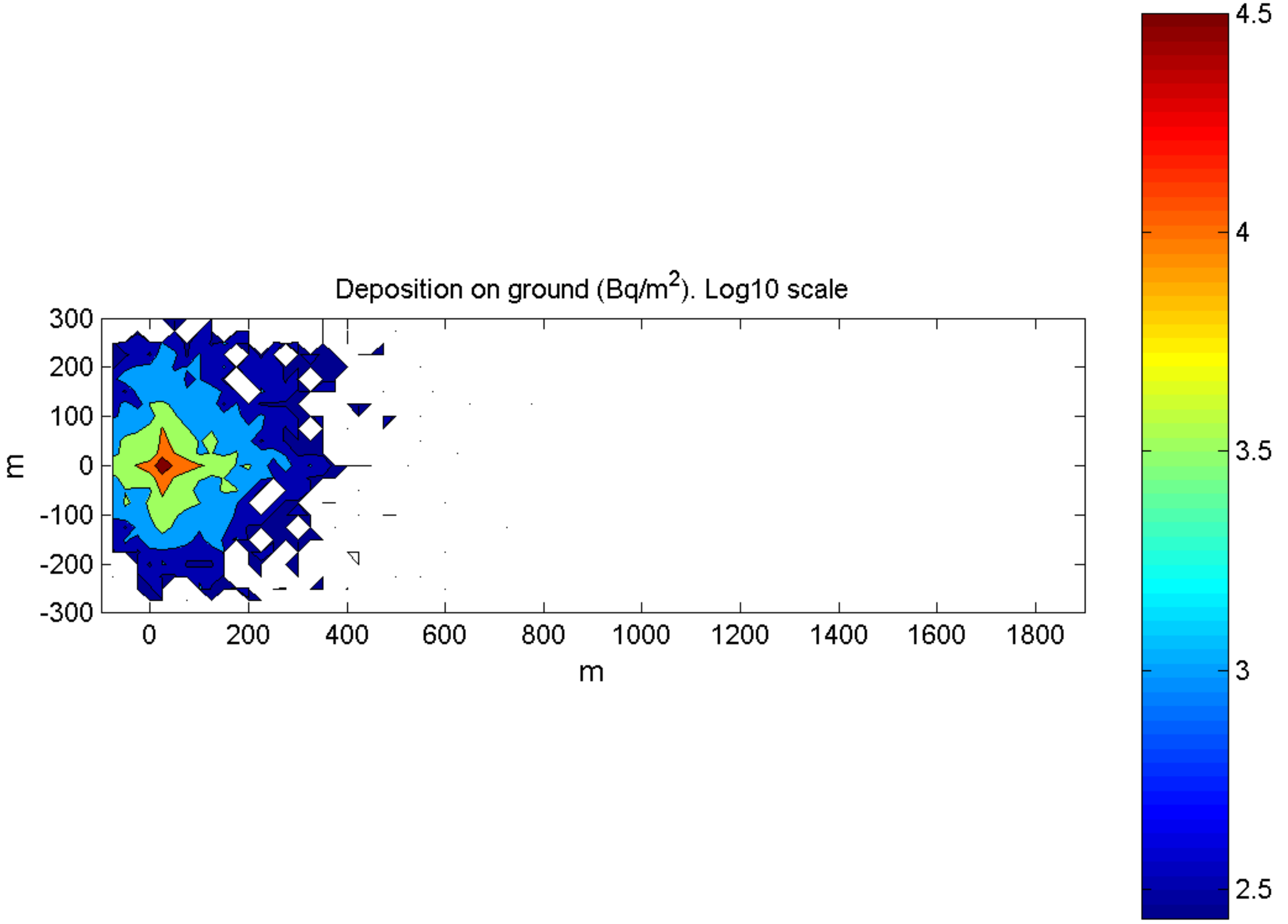


5 m grid



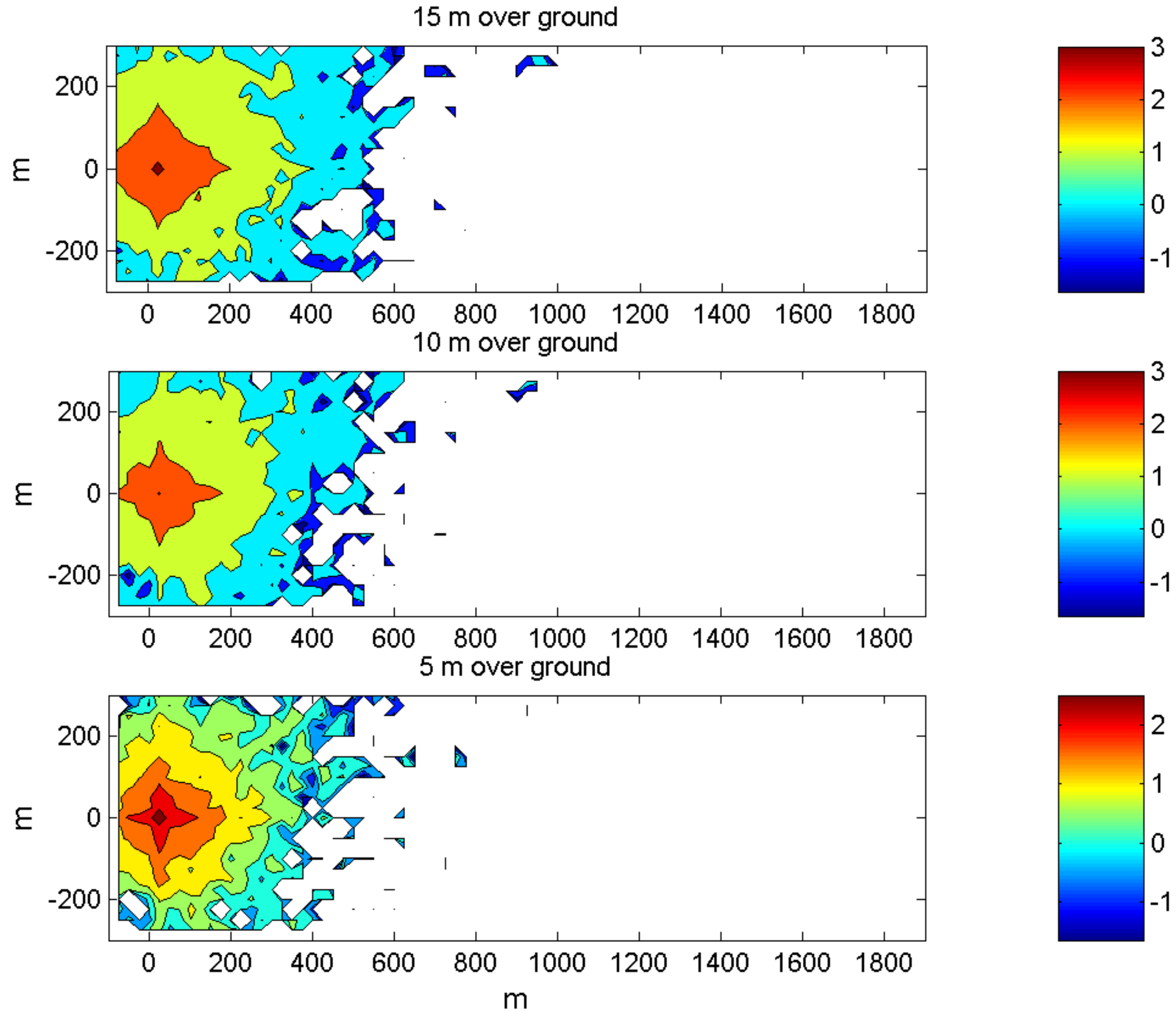
1 m grid

Test 4



Deposition on ground (Bq/m2). Log10 scale
300
200
100
0
-100
-200
-300
m
0
200
400
600
800
1000
1200
1400
1600
1800
m
4.5
4
3.5
3
2.5

Test 4



TIC in air, 15 min after explosion (Bq/m^3×min).
Log scale