Development of a Puff Dispersion Model for Short Term Accidental Releases, Based on the ADMS4 Model

ADMS-STAR2

Jocelyn Harvey

UK Food Standards Agency

Outline of Presentation

- Design Philosophy
- Model Requirements
- Technical Features
  - Meteorology
  - Dispersion
  - Releases
  - Source estimation
  - Output
- The Future

Design Philosophy

- Food Standards Agency responsible for protecting the public from contaminated food
- Deposition to the food chain
- Accidental releases – short term models
- Fires & explosions
- Limited data in early stages
- User familiarity

Model Requirements (1)

- Model instantaneous & extended releases
- Below & above boundary layer dispersion
- Spatially & temporally varying 3D met.
- Gaseous & particulate releases
- Varying surface features & complex terrain
- Source estimation from monitoring data
- Radionuclide decay terms
- Deposition isopleths to GIS

Model Requirements (2)

But also can run with:

- Smooth plane and constant surface parameters
- Simple default emission and deposition parameters
- Output options accessible without GIS requirement

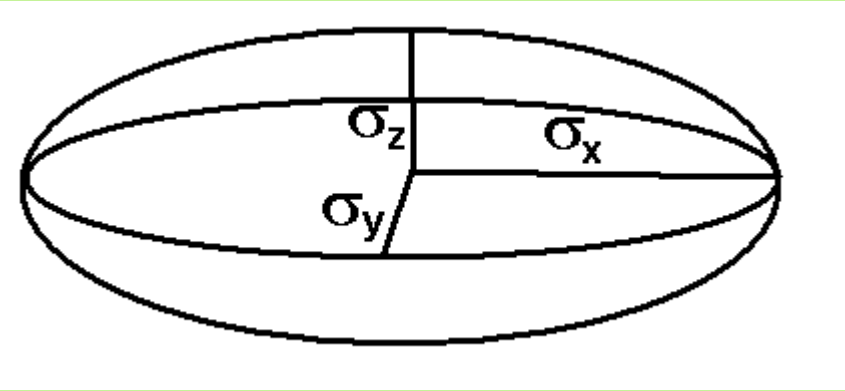
Model Requirements (3)

It was also decided that:

- Would not contain any source terms
- Use observed/estimated
  - Source temperature
  - TNT equivalent
  - Cloud/plume rise
- Would use empirical cloud/plume rise models

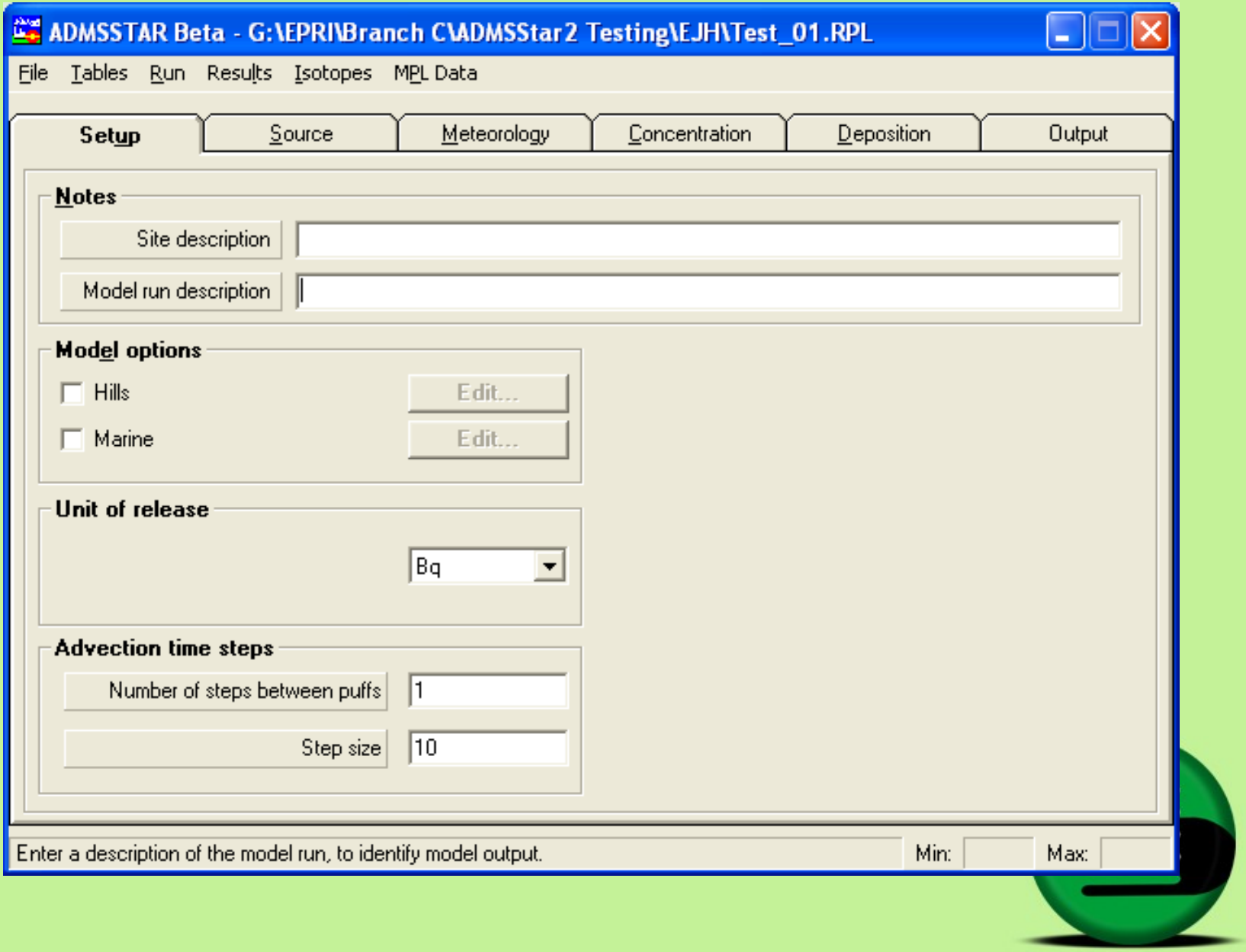
Dispersion (1)

- Lagrangian puff model
- Uses ADMS dispersion algorithms
- Instantaneous finite puff
- Puff responds to mean wind flow and turbulence parameters at puff centre

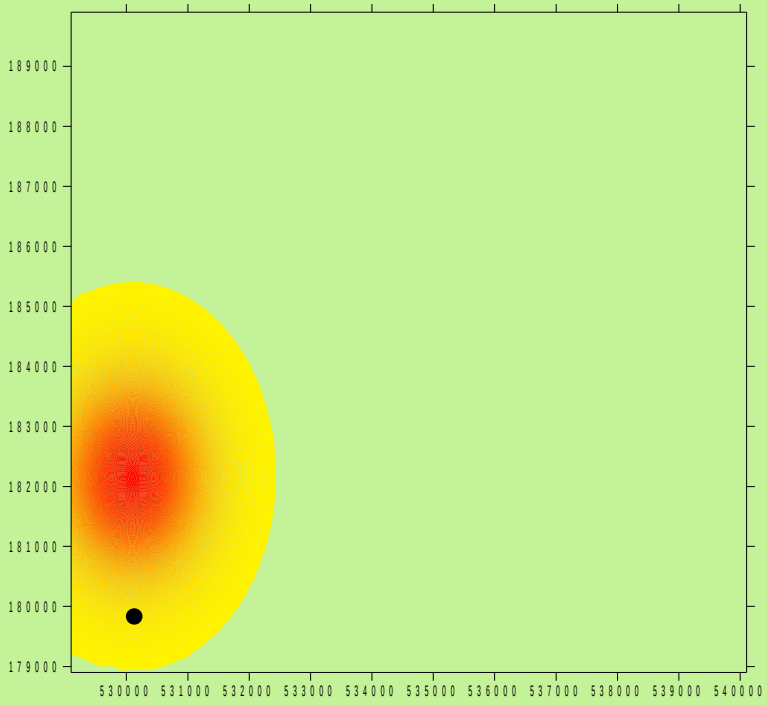


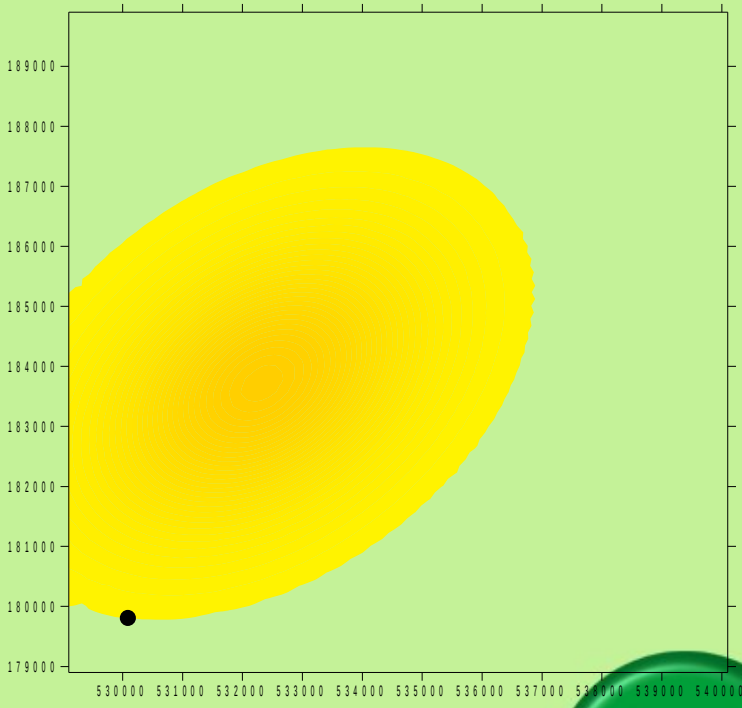
Dispersion (2)

- Continuous release consist of a series of puffs
- Puffs advected on time scales less than meteorological step time scales
- Time history of each puff is different
  - allows variable meteorological & complex topography
- User specified puff durations and time steps


ADMSSTAR Beta - G:\EPRI\Branch C\ADMSStar2 Testing\EJH\Test_01.RPL
File Tables Run Results Isotopes MPL Data
Setup Source Meteorology Concentration Deposition Output
Notes
Site description
Model run description
Model options
Hills
Edit...
Marine
Edit...
Unit of release
Bq
Advection time steps
Number of steps between puffs
1
Step size
10
Enter a description of the model run, to identify model output.
Min:
Max:

Concentration at 15 and 30 minutes in variable wind conditions

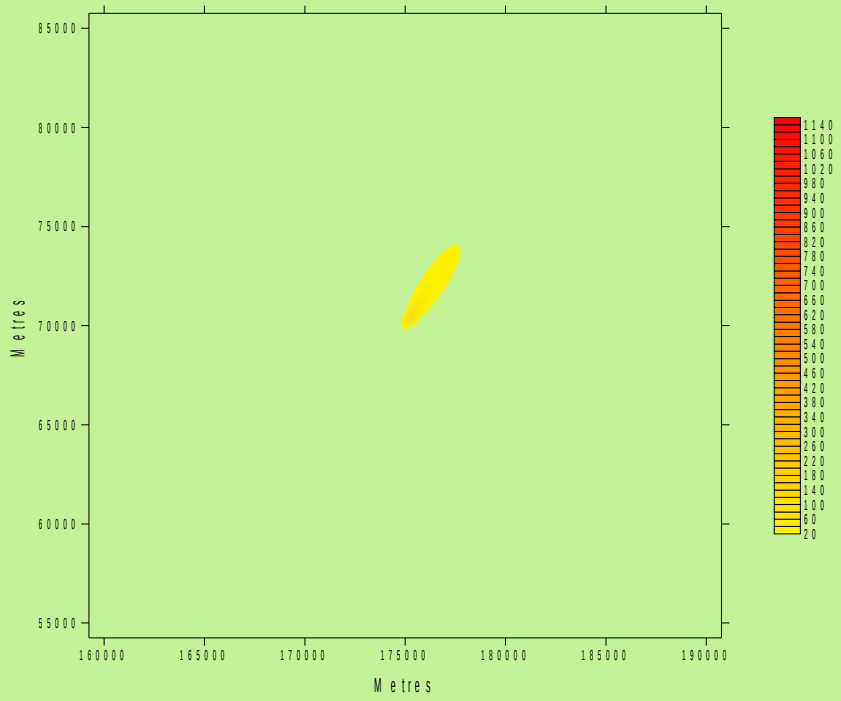


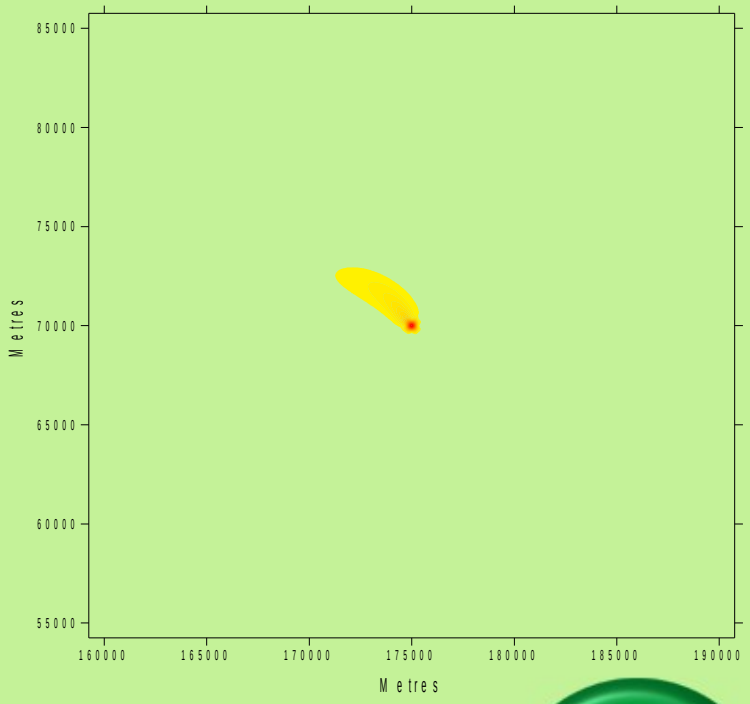


Dispersion (3)

- Complex terrain - mean air flow & turbulence parameters modelled using FLOWSTAR within embedded domain (smooth surface outside of domain)
- Dispersion dependant on FLOWSTAR derived parameter values in domain
- For fixed sites (nuclear power plants), digitised contour maps may be pre-prepared
- ADMS marine dispersion module

Total deposition for two runs (with and without complex terrain)



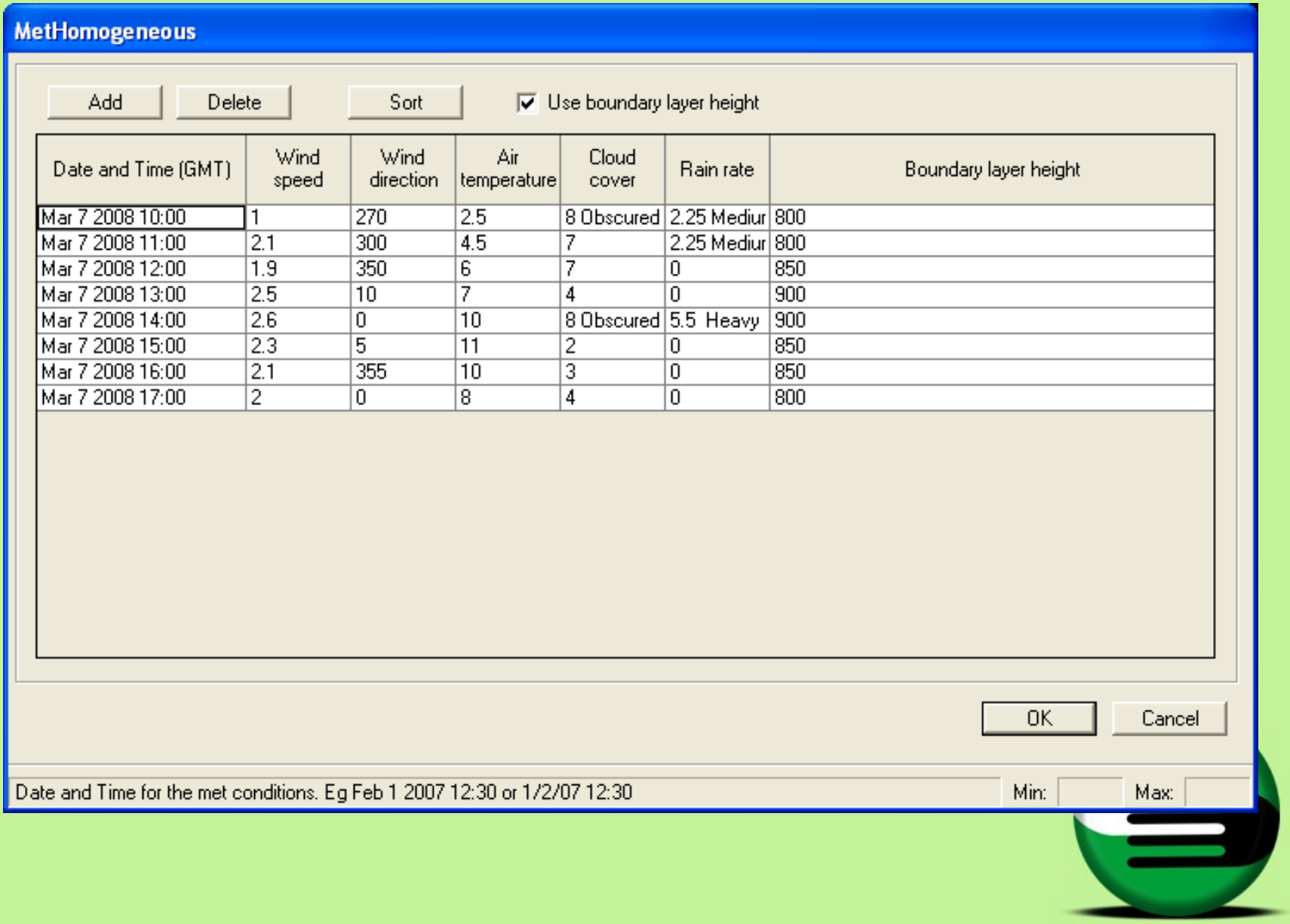


Dispersion (4)

- Dry deposition may be:
  - ‘Standard’
  - User specified
  - ‘Calculated’
- ‘Calculated’ dependant on pollutant and surface parameters (z_o, u_*, gravitational and resistance components)
- 10 particle sizes, inert, reactive, non-reactive gases
- Surface roughness files

Meteorological Data (1)

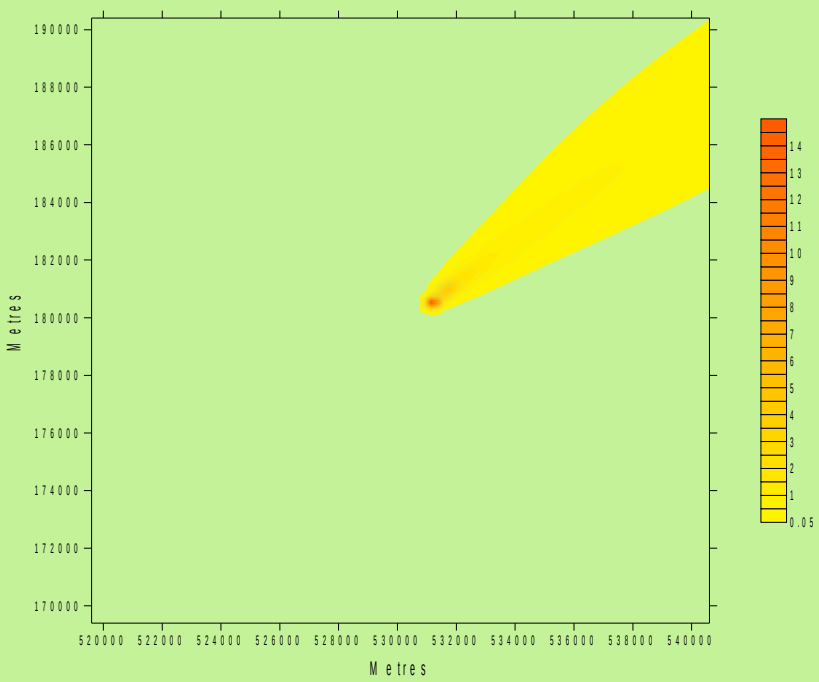
- May be surface observational data (ADMS format) with up to 72 met. lines (minimum resolution of 30 minutes)
- 3D spatially and temporally varying NWP data (typically 4-12 km resolution, up to 3000x3000 km grid domain)
- Release site observational met data can be used with NWP data

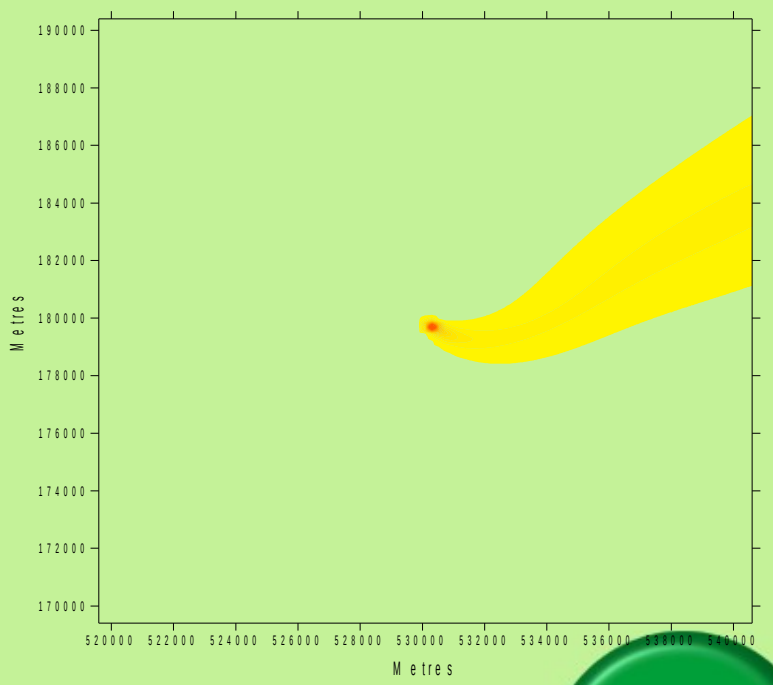

MetHomogeneous
Add
Delete
Sort
Use boundary layer height
Date and Time (GMT)
Wind speed
Wind direction
Air temperature
Cloud cover
Rain rate
Boundary layer height
Mar 7 2008 10:00 1 270 2.5 8 Obscured 2.25 Mediur 800
Mar 7 2008 11:00 2.1 300 4.5 7 2.25 Mediur 800
Mar 7 2008 12:00 1.9 350 6 7 0 850
Mar 7 2008 13:00 2.5 10 7 4 0 900
Mar 7 2008 14:00 2.6 0 10 8 Obscured 5.5 Heavy 900
Mar 7 2008 15:00 2.3 5 11 2 0 850
Mar 7 2008 16:00 2.1 355 10 3 0 850
Mar 7 2008 17:00 2 0 8 4 0 800
OK
Cancel
Date and Time for the met conditions. Eg Feb 1 2007 12:30 or 1/2/07 12:30
Min:
Max:

Meteorological Data (2)

- Spatially varying NWP data includes:
  - 3D flow & temperature fields
  - 2D rain fall rate, cloud cover, surface roughness, boundary layer height
- ADMS met processor run at each grid point, with dispersion properties a function of space and time
- Observed & FLOWSTAR domain met. data *relaxes* to NWP

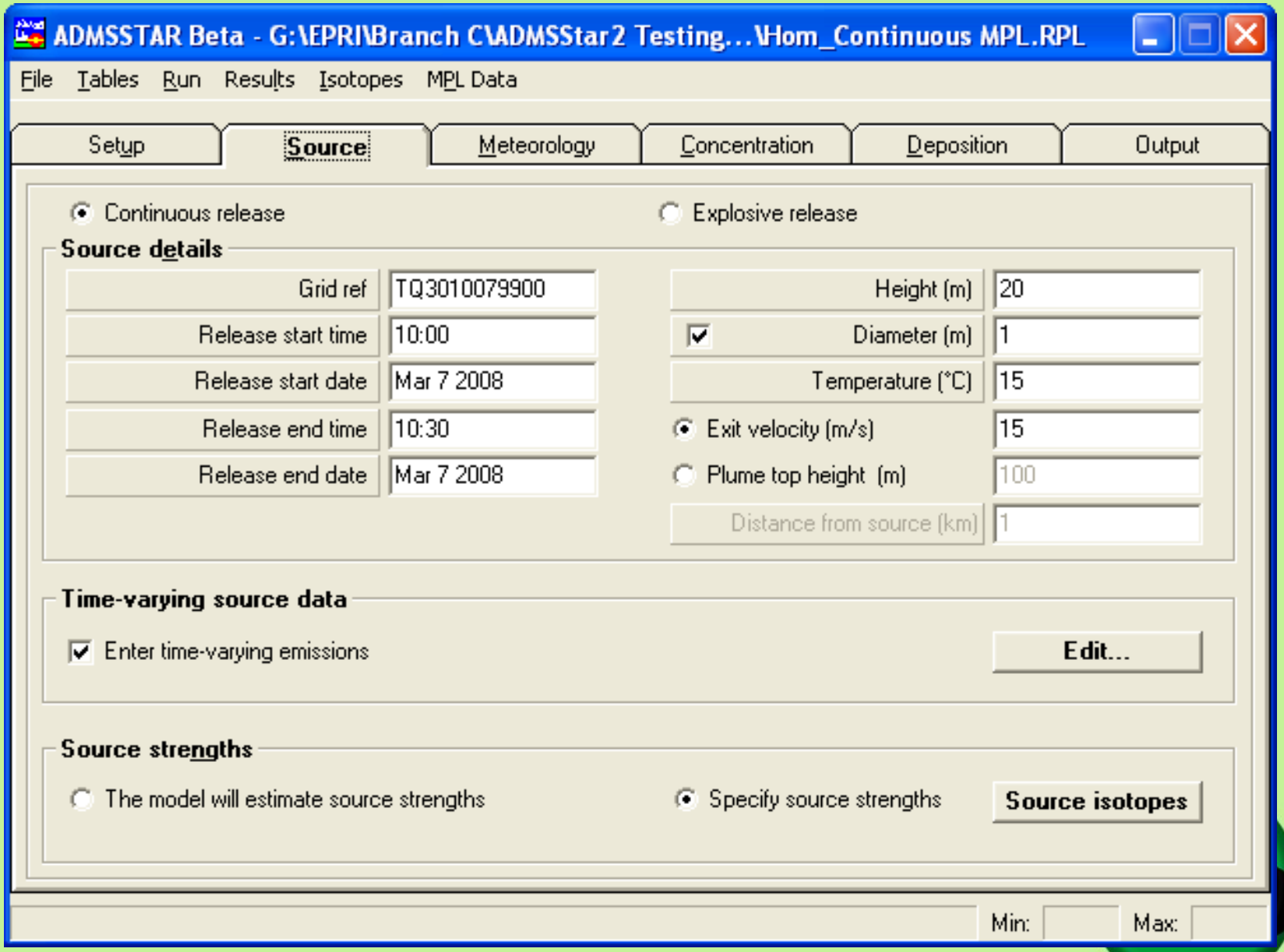
Total deposition (with and without observed site met. data)





Releases (1)

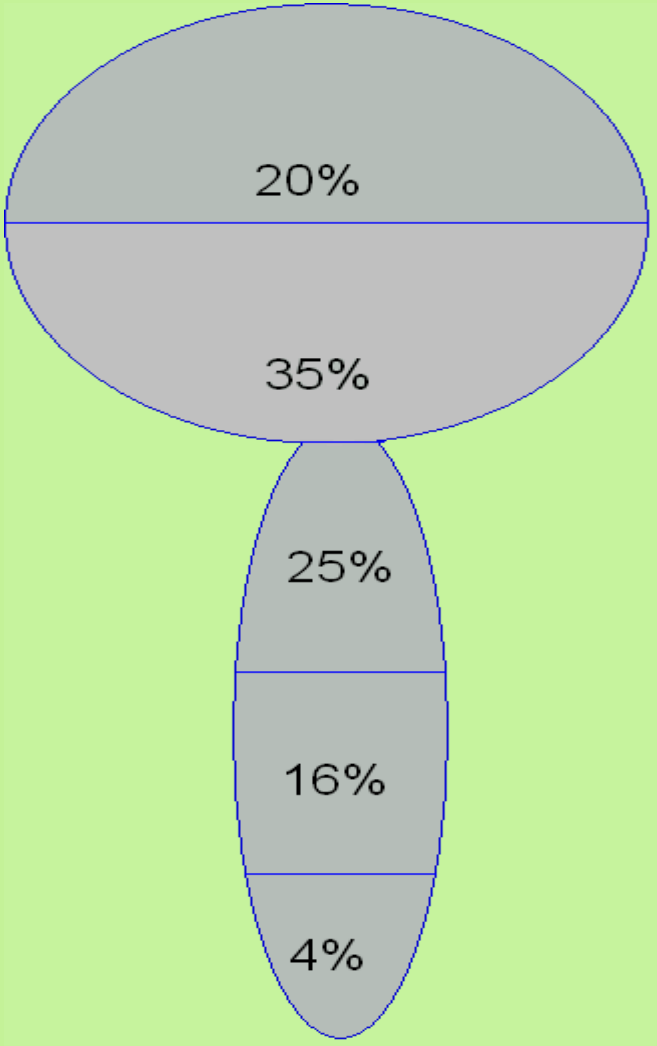
- Thermal releases
  - Release rate (Bq/s or g/s)
  - Temperature & exit velocity or
  - Temperature, plume top height and plume top distance
- Brigg's equation used; inverted to derive exit velocity
- Time varying emission rates

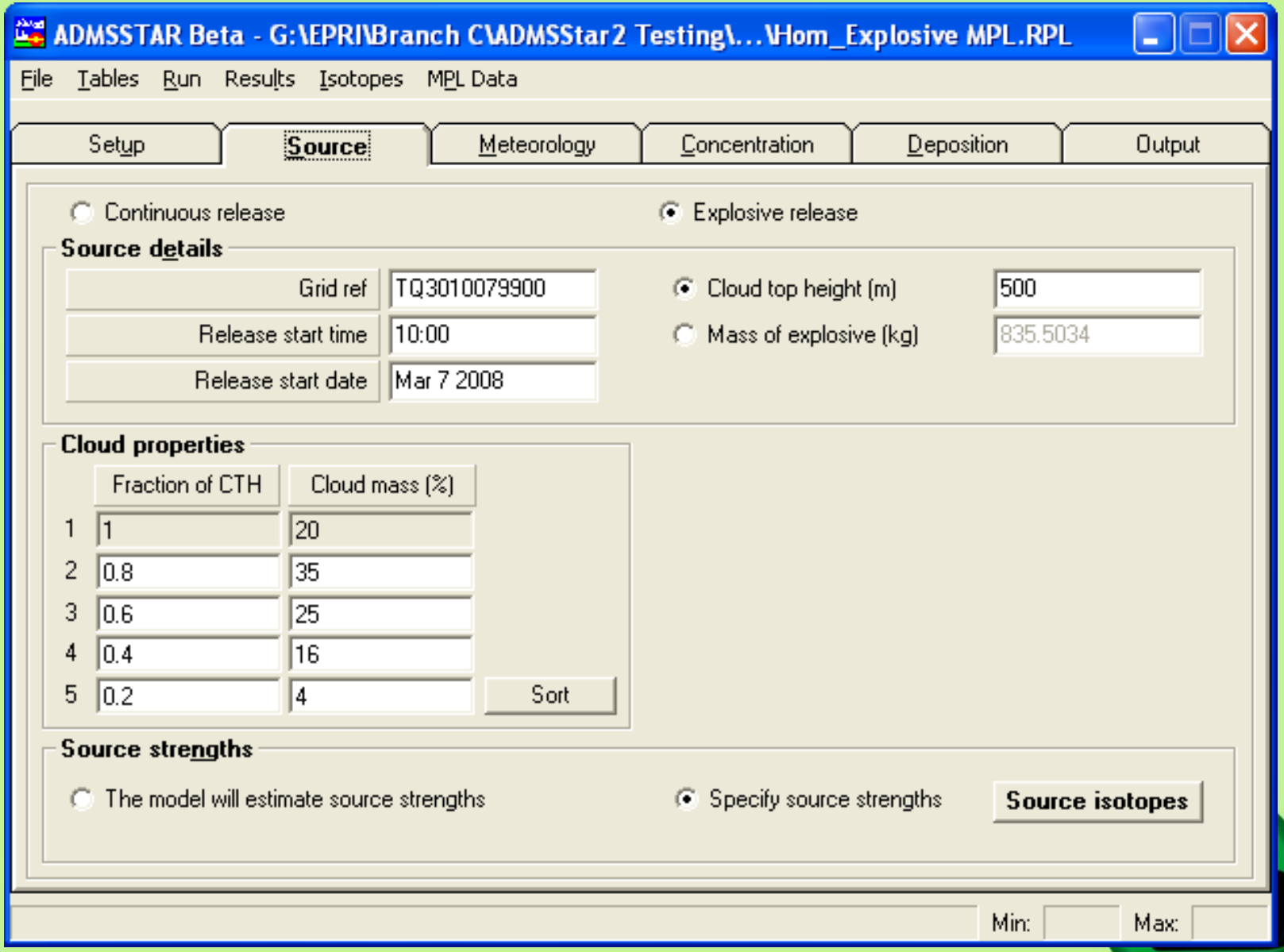

ADMSSTAR Beta - G:\EPRI\Branch C\ADMSStar2 Testing...\Hom_Continuous MPL.RPL
File Tables Run Results Isotopes MPL Data
Setup Source Meteorology Concentration Deposition Output
Continuous release
Explosive release
Source details
Grid ref
TQ3010079900
Release start time
10:00
Release start date
Mar 7 2008
Release end time
10:30
Release end date
Mar 7 2008
Height (m)
20
Diameter (m)
1
Temperature (°C)
15
Exit velocity (m/s)
15
Plume top height (m)
100
Distance from source (km)
1
Time-varying source data
Enter time-varying emissions
Edit...
Source strengths
The model will estimate source strengths
Specify source strengths
Source isotopes
Min:
Max:

Releases (2)

- Explosive releases
  - Mass (total activity) of dispersed material
  - TNT equivalent or
  - Cloud top height
- 10 user defined or default mass/particle fractions
- Boundary layer penetrated, cloud modelled as separate stem & cap puffs
- Boundary layer contained releases assume uniform vertical distribution

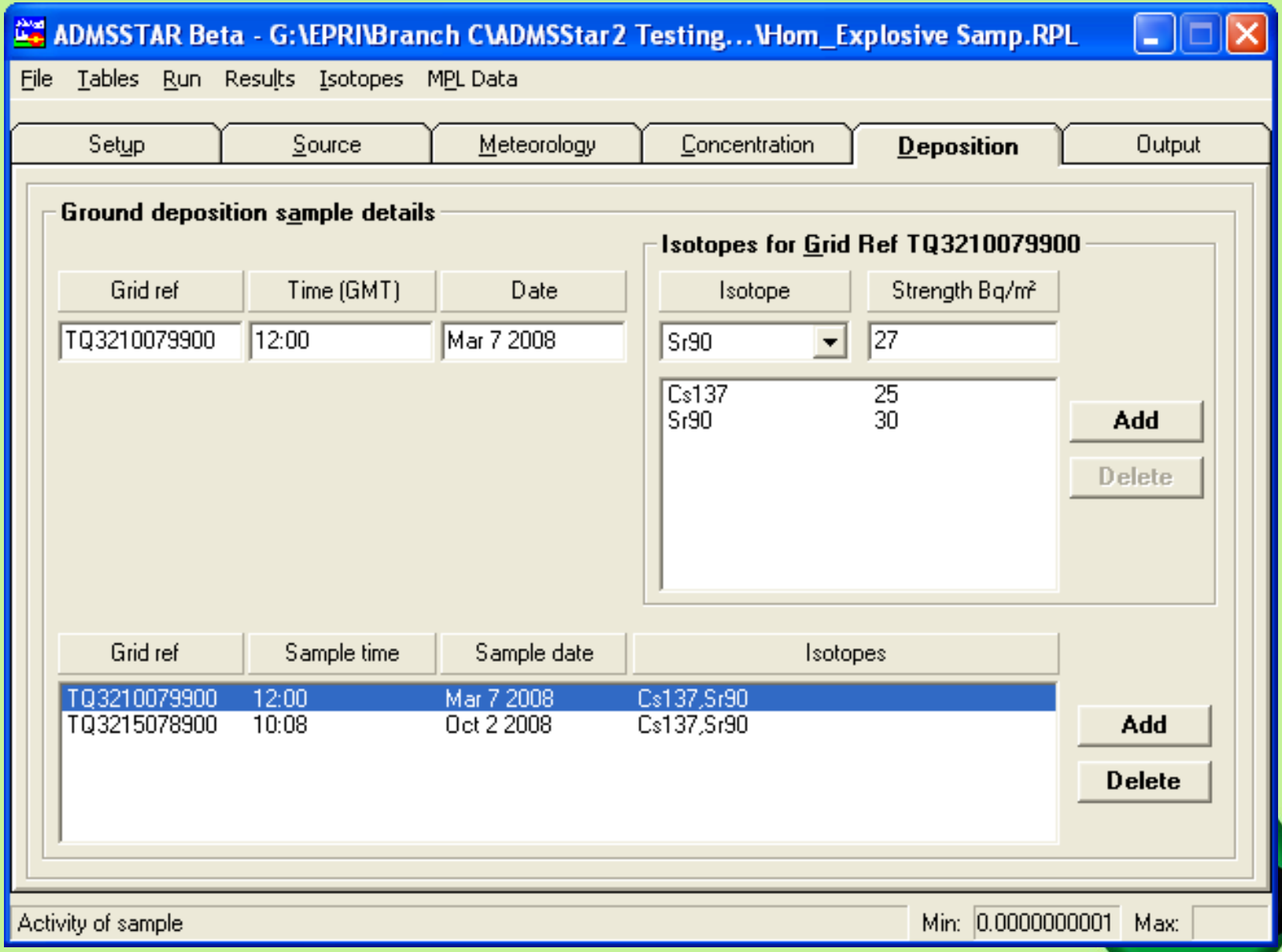
Segmented cloud




ADMSSTAR Beta - G:\EPRI\Branch C\ADMSStar2 Testing\...\Hom_Explosive MPL.RPL
File Tables Run Results Isotopes MPL Data
Setup Source Meteorology Concentration Deposition Output
Continuous release
Explosive release
Source details
Grid ref
TQ3010079900
Release start time
10:00
Release start date
Mar 7 2008
Cloud top height (m)
500
Mass of explosive (kg)
835.5034
Cloud properties
Fraction of CTH
Cloud mass (%)
1 1 20
2 0.8 35
3 0.6 25
4 0.4 16
5 0.2 4
Sort
Source strengths
The model will estimate source strengths
Specify source strengths
Source isotopes
Min:
Max:

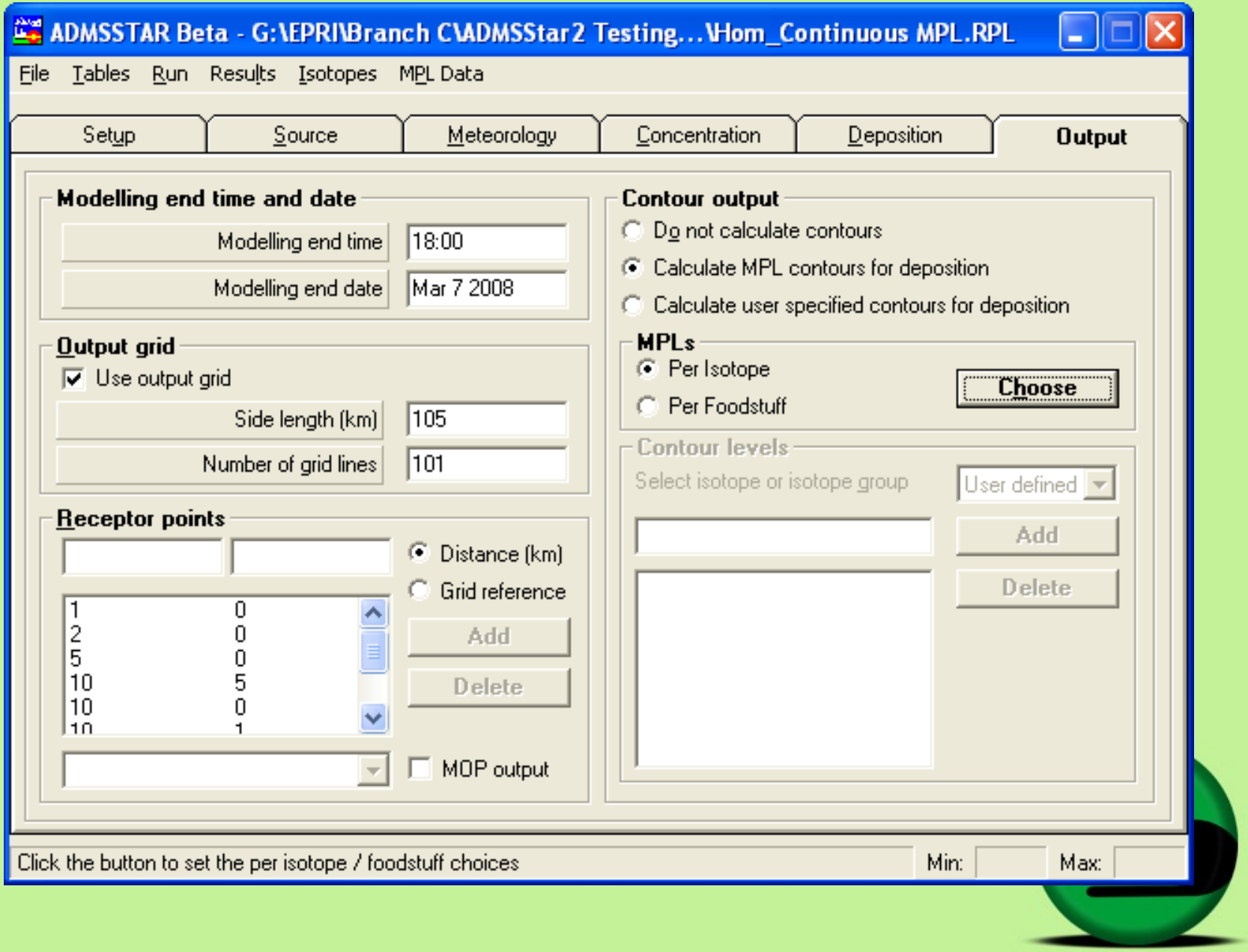
Source Estimation

- User can enter
  - Ground level air concentrations
  - Ground deposition measurements
- Model back calculates to estimate source
- Forward calculation of dispersion using mean source estimates
- Data entry via model or *ArcGIS* interface
- Radioactive decay allowed for


ADMSSTAR Beta - G:\EPRI\Branch C\ADMSStar2 Testing...\Hom_Explosive Samp.RPL
File Tables Run Results Isotopes MPL Data
Setup Source Meteorology Concentration Deposition Output
Ground deposition sample details
Grid ref Time (GMT) Date
TQ3210079900 12:00 Mar 7 2008
Isotopes for Grid Ref TQ3210079900
Isotope Strength Bq/m²
Sr90 27
Cs137 25
Sr90 30
Add
Delete
Grid ref Sample time Sample date Isotopes
TQ3210079900 12:00 Mar 7 2008 Cs137,Sr90
TQ3215078900 10:08 Oct 2 2008 Cs137,Sr90
Add
Delete
Activity of sample
Min: 0.0000000001
Max:

Output (1)

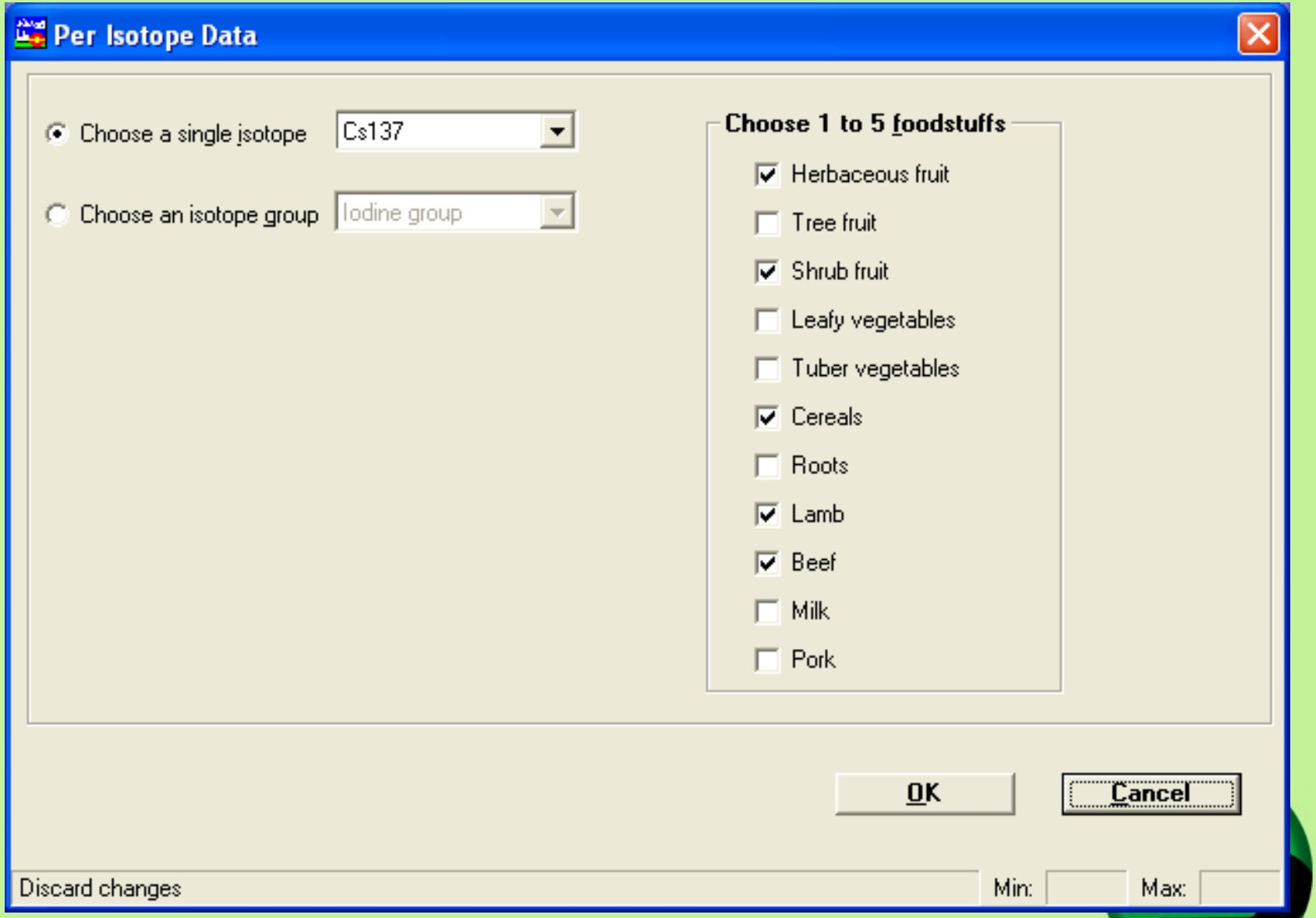
- Gridded output (101 points)
- 25 user defined locations
- Total deposition (and daughter products)
- Instantaneous ground level air concentrations at end of met. Line
- Total deposition plots along 10 degree intervals
- Meteorological outputs at one user defined location


ADMSSTAR Beta - G:\EPRI\Branch C\ADMSStar2 Testing...\Hom_Continuous MPL.RPL
File Tables Run Results Isotopes MPL Data
Setup Source Meteorology Concentration Deposition Output
Modelling end time and date
Modelling end time 18:00
Modelling end date Mar 7 2008
Output grid
Use output grid
Side length (km) 105
Number of grid lines 101
Receptor points
1 0
2 0
5 0
10 5
10 0
Distance (km)
Grid reference
Add
Delete
MOP output
Contour output
Do not calculate contours
Calculate MPL contours for deposition
Calculate user specified contours for deposition
MPLs
Per Isotope
Per Foodstuff
Choose
Contour levels
Select isotope or isotope group
User defined
Add
Delete
Click the button to set the per isotope / foodstuff choices
Min:
Max:

Output (2)

Prime output is to *ArcGIS*

- Deposition isopleths
  - User defined levels
  - MPL (EU Limits), single isotope, isotope groups or food types
- *Surfer* contoured plots


Per Isotope Data
Choose a single isotope
Cs137
Choose an isotope group
Iodine group
Choose 1 to 5 foodstuffs
Herbaceous fruit
Tree fruit
Shrub fruit
Leafy vegetables
Tuber vegetables
Cereals
Roots
Lamb
Beef
Milk
Pork
OK
Cancel
Discard changes
Min:
Max:

Future Developments

- User testing and familiarization
- Validation exercise
  - basic defaults
  - ‘expert’ knowledge
  - in-between
- Modifications
- Developments & enhancements

Acknowledgments

CERC for use of some of their *picturesque* outputs

Drs Christine McHugh and Martin Seaton of CERC