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Presentation to

UK Atmospheric Dispersion Modelling Liaison Committee (ADMLC)

ADMSSTAR – a model of puff dispersion

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Content

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- ADMS – plumes and puffs
- Requirements
- Puff dispersion model overview
- Spatially varying meteorology
- Variable terrain and surface roughness
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- Conclusions

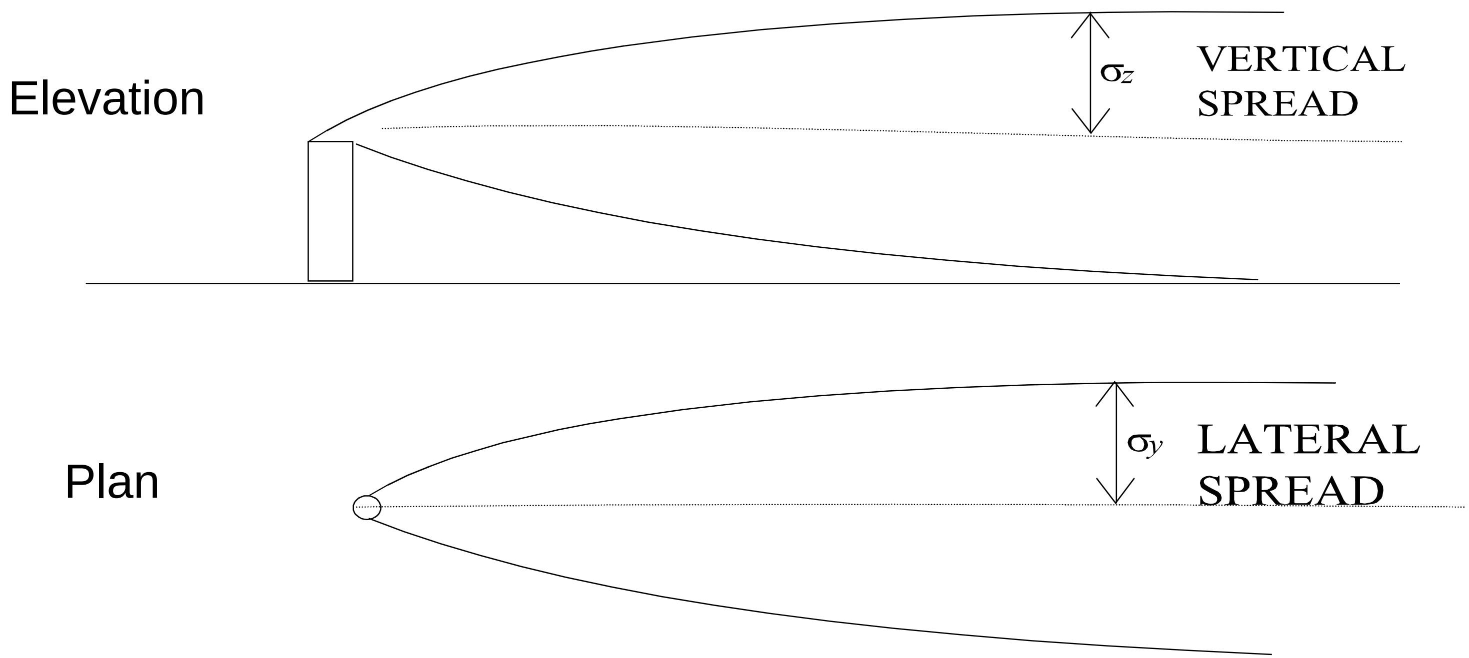
Applications

Currently being implemented in ADMSSTAR 2

- Produced for the Food Standards Agency
  - Interested in accidental and explosive releases
- Includes existing features of ADMSSTAR 1
  - Radioactive decay
  - Back calculation from sample strengths
  - Calculation of MPL contours

ADMS - Plumes

- Steady state infinite release



- Long term results are the average over a series of independent, infinite, steady state plumes

ADMS - puffs

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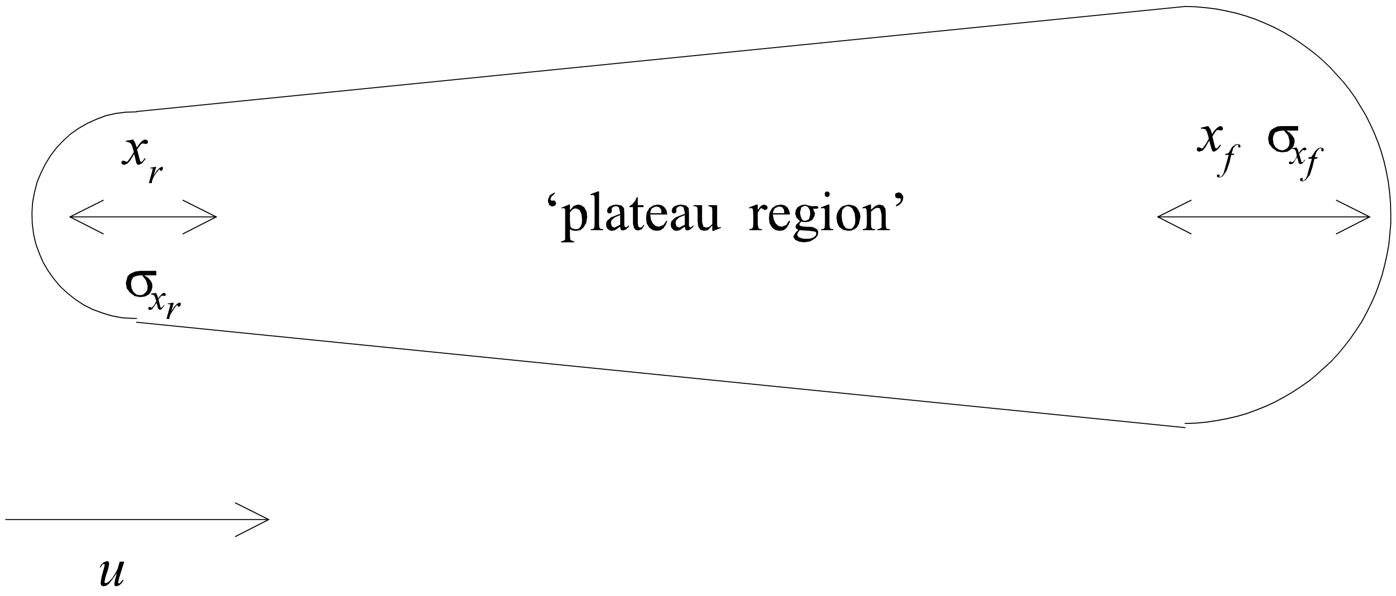
- Puffs in ADMS 4 also assume steady met conditions but release has finite duration
- Concentration depends on time since release and puff has a defined front and rear



ADMS - puffs

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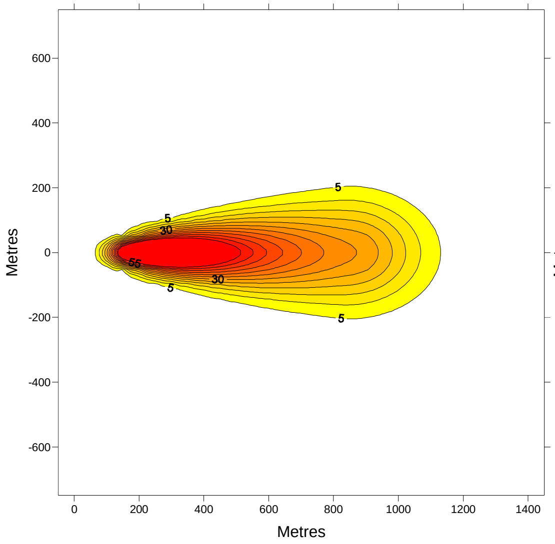
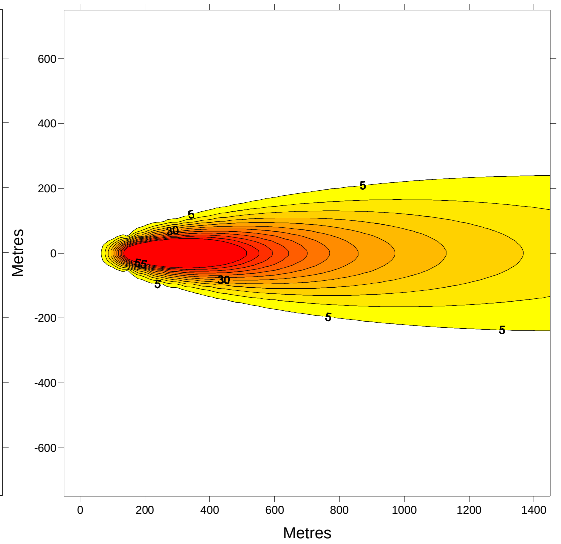
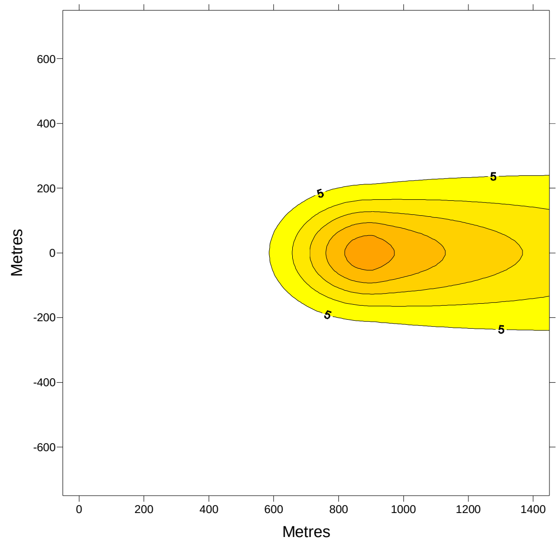


180s



300s



420s

Release lasts until 300s

Requirements

- For short releases temporal variation of meteorology can be important

- Ability to handle spatially varying meteorology
  - flow field: Horizontal and vertical wind speed components
  - boundary layer properties: e.g. boundary layer height, surface heat flux

- Generate flow field from terrain data and upwind meteorological conditions

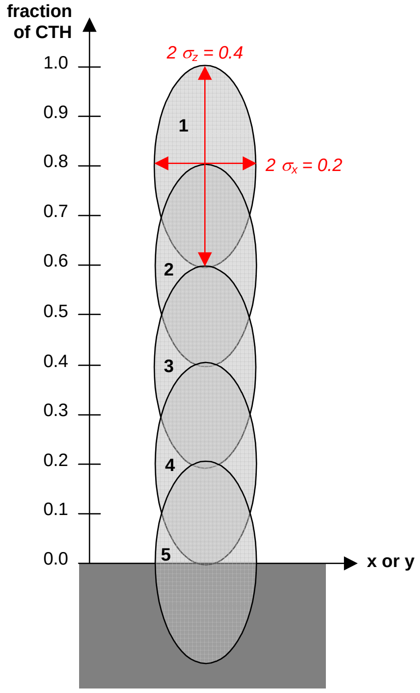
Method - overview

Multiple puff approach

- Overview
  - A sequence of instantaneous puffs released
  - Each puff advected on a time scale smaller than time scale on which the meteorology changes
  - Concentration field is the sum of the concentration fields of the individual puffs
- However
  - Time history of <u>each</u> puff is different, so more complex than steady state
  - Longer run time
- Advantages
  - Flexible, allows concentration with time with temporally and spatially varying meteorology
  - Allows incorporation of both small scale and large scale meteorology

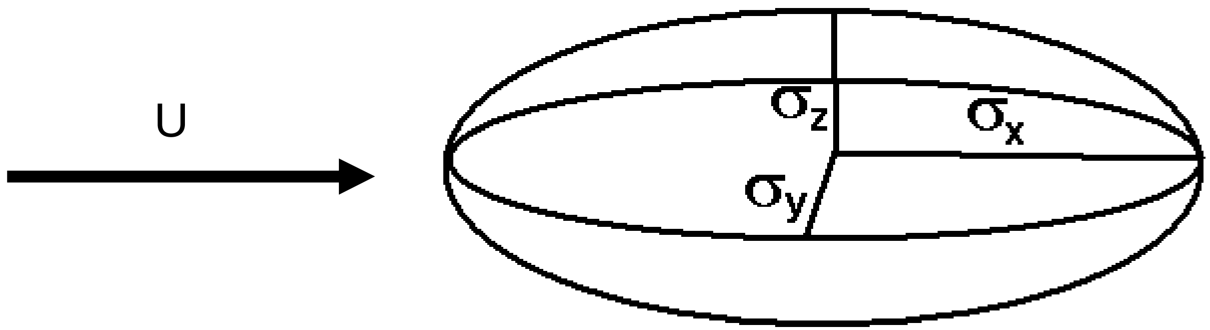
Release types

- Release can either be continuous or explosive
  - Continuous release has a defined start and end time, a single initial puff and more are added as the release continues
  - Explosive release is a single event with 5 initial puffs and no more added over time



Method – details 1

Instantaneous puff



Puff properties

- Centre of mass
- Spread parameters
- Amount of material
- Deposition properties

Method – details 2

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- Centre of mass advected based on wind velocity at mean puff height

$$X(t+\Delta t) = X(t) + \Delta t U_x(t)$$

$$Y(t+\Delta t) = Y(t) + \Delta t U_y(t)$$

$$Z(t+\Delta t) = Z(t) + \Delta t\left(U_z(t) + W_{pr} + W_s\right)$$

- Takes into account plume rise and gravitational settling
- Meteorological parameters calculated at mean puff height

Method – details 3

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- Spreading parameters, relative to local streamline, calculated based on change assuming current met conditions persisted since start of release e.g.

$$\sigma_y^2(t+\Delta t) = \sigma_y^2(t) + \bar{\sigma}_y^2(t+\Delta t) - \bar{\sigma}_y^2(t)$$

- With the plume spread assuming the current met conditions persisted since the start of release

$$\bar{\sigma}_y(t)$$

calculated using the standard ADMS plume equations

Method – details 4

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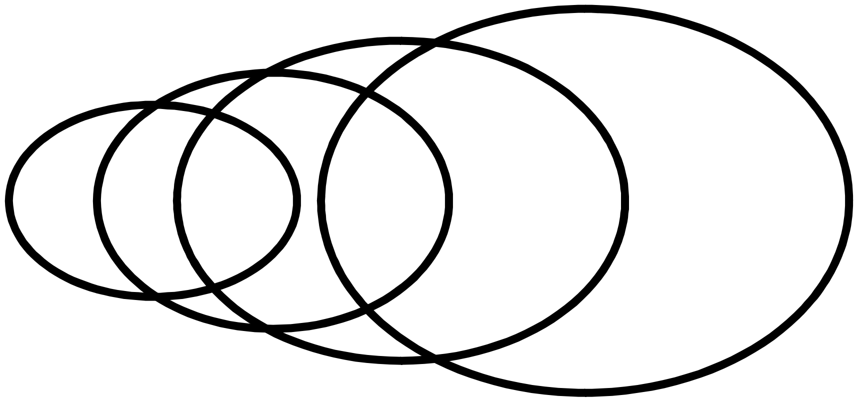
- Deposition equations adapted to take into account instantaneous puff approach
- Concentration for individual puff calculated assuming a Gaussian puff (X,Y directions, Z direction like ADMS plume)
- Overall concentration calculated by summing concentrations due to individual puffs



- Total accumulated deposition calculated by summing deposition due to each puff at each time step

Results - concentration

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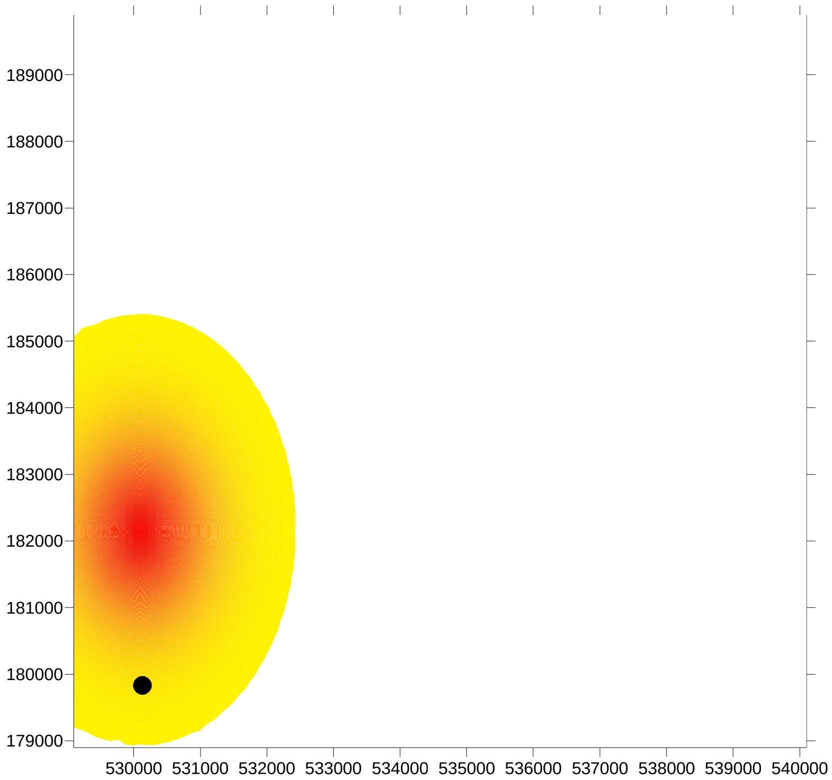
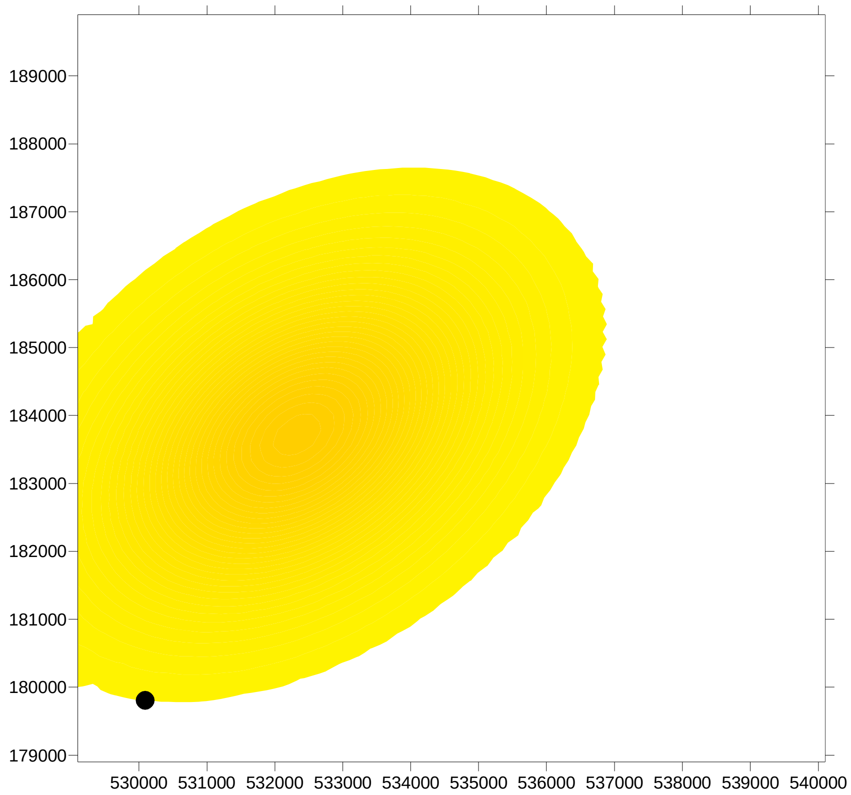
Concentration for a single puff after 15 minutes and 30 minutes. The wind direction is 180^{o} for the first 15 minutes and 235^{o} for the second



15 Minutes



30 Minutes

Results – continuous release

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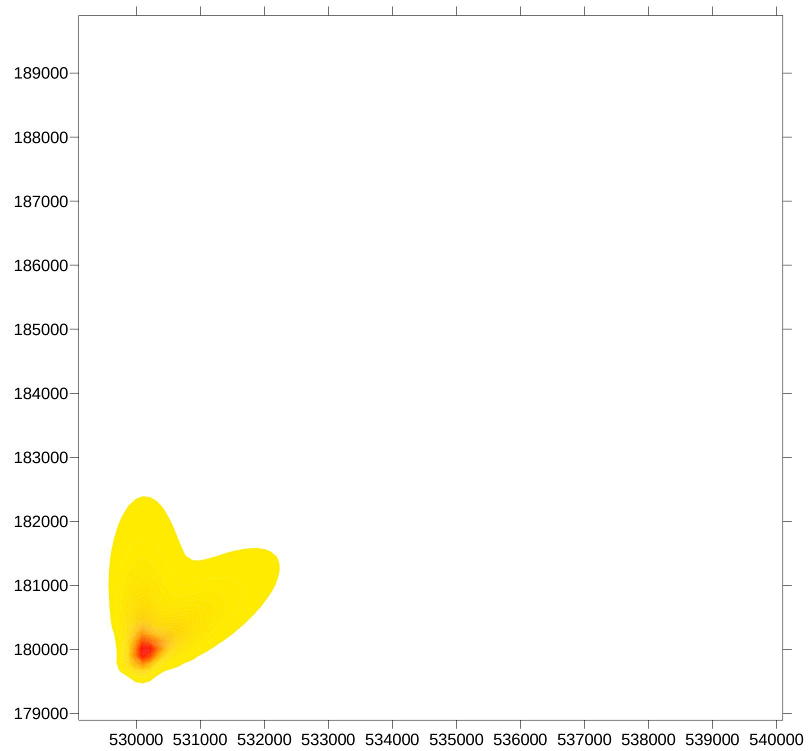
Concentration and total accumulated deposition results for a continuous release after two 15 minute met periods with wind directions of 180º and 235º

Concentration



Deposition

Results – total deposition

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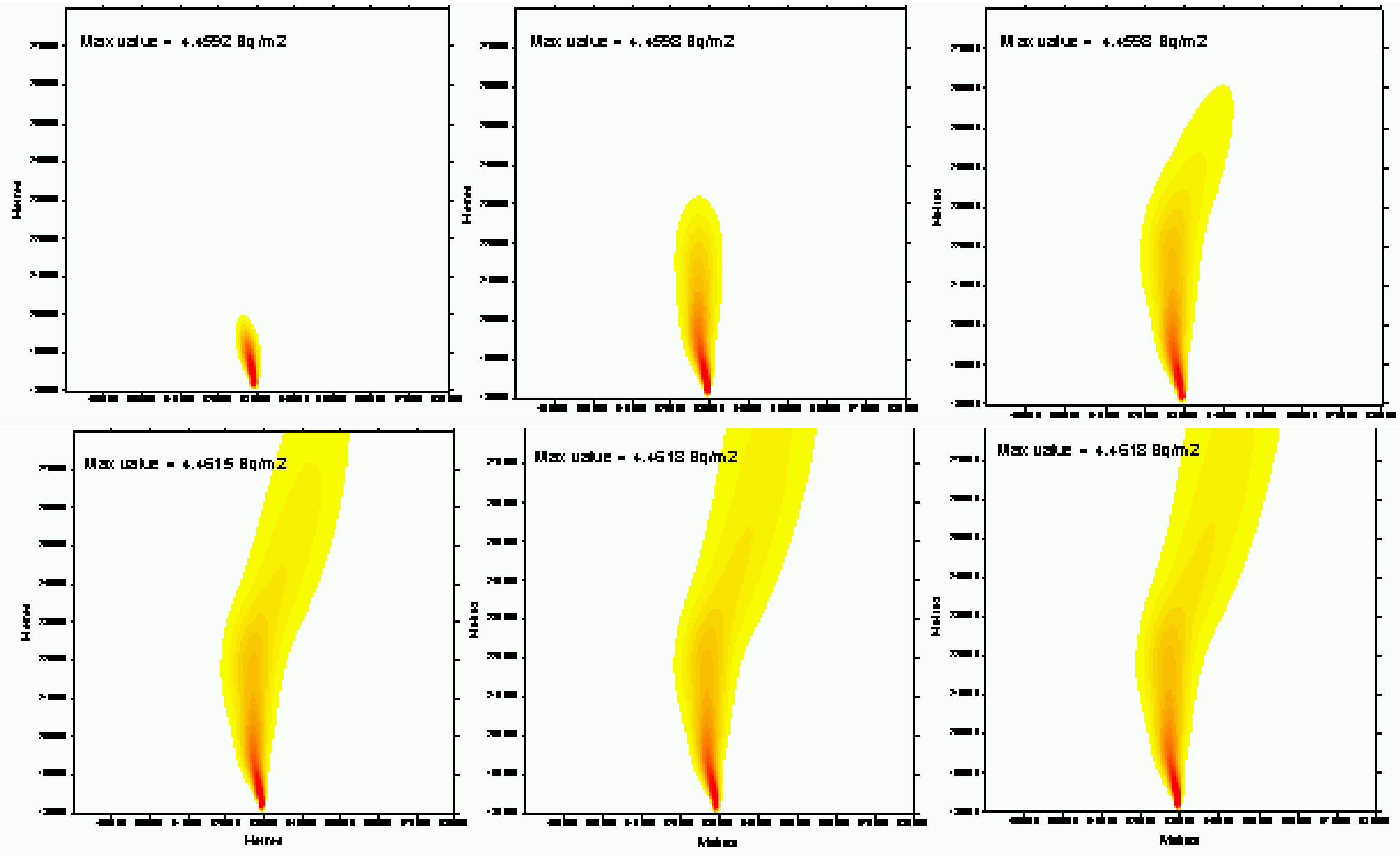
Total accumulated deposition for a 5 minute release over a series of met periods with differing meteorological conditions



Spatially varying meteorology

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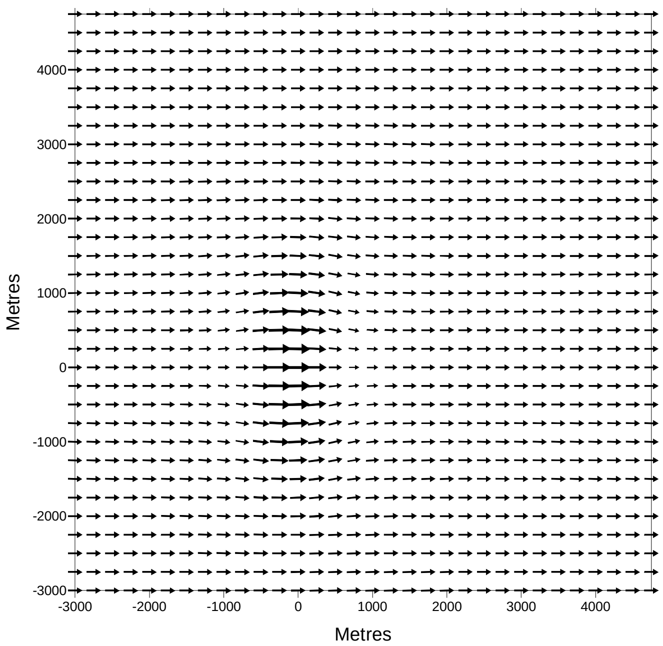
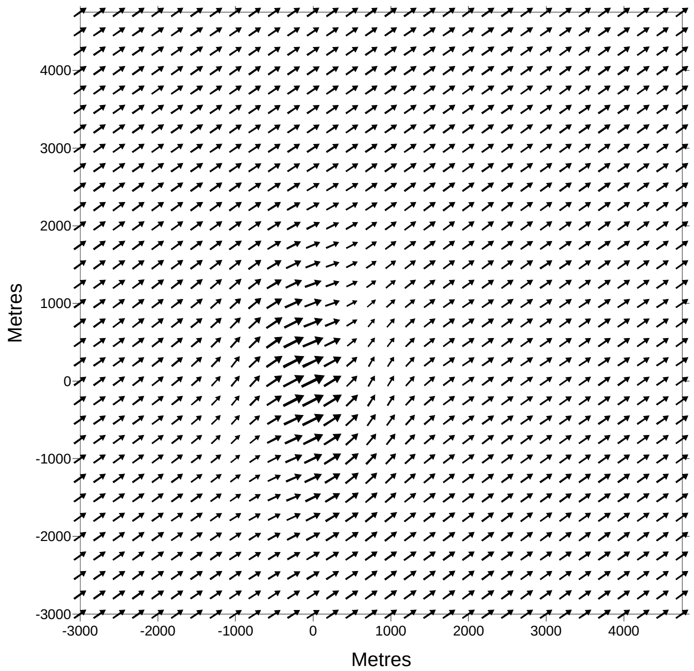
- Extend this to be able to deal with spatially varying meteorology



Hour 1



Hour 2

- Meso scale meteorological data supplied by the Met Office in NetCDF format at 4km or 12km horizontal resolution

Spatially varying meteorology 2

- Spatially varying meteorology includes
  - 3D flow fields
  - 3D temperature field
  - 2D rain fall rate, cloud cover, surface roughness and boundary layer height

- This means ADMS met variables need to be calculated across the meteorological grid.

Spatially varying meteorology 3

- ADMS met processor run at each grid point of the input meteorology grid to calculate met properties

- Dispersion calculations carried out in the same way as for spatially homogeneous met data but now met properties are a function of space and time e.g.

$$X(t+\Delta t) = X(t) + \Delta t U_x(\mathbf{X}(t), t)$$

Results – spatially varying meteorology

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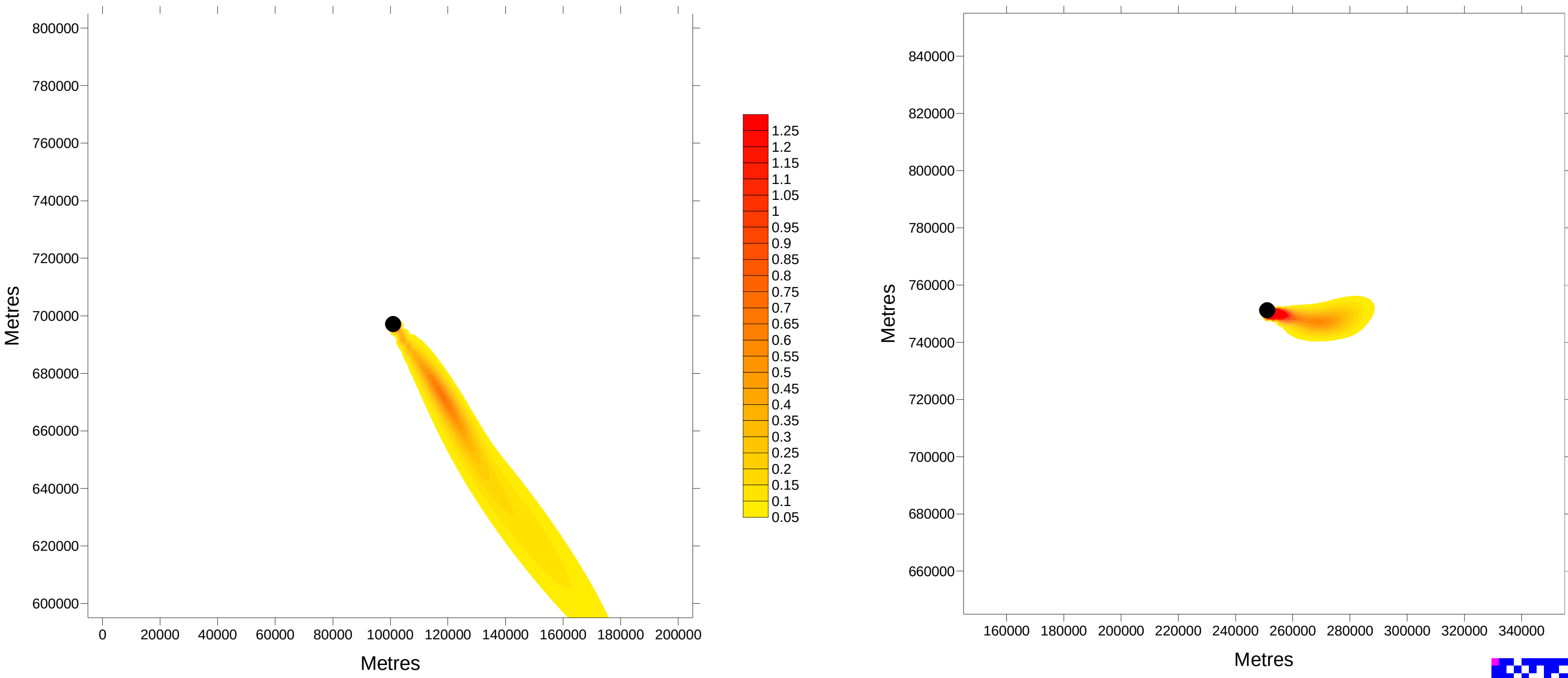
Total deposition for two runs with the same set up and for the same time period, the only difference is in the source location

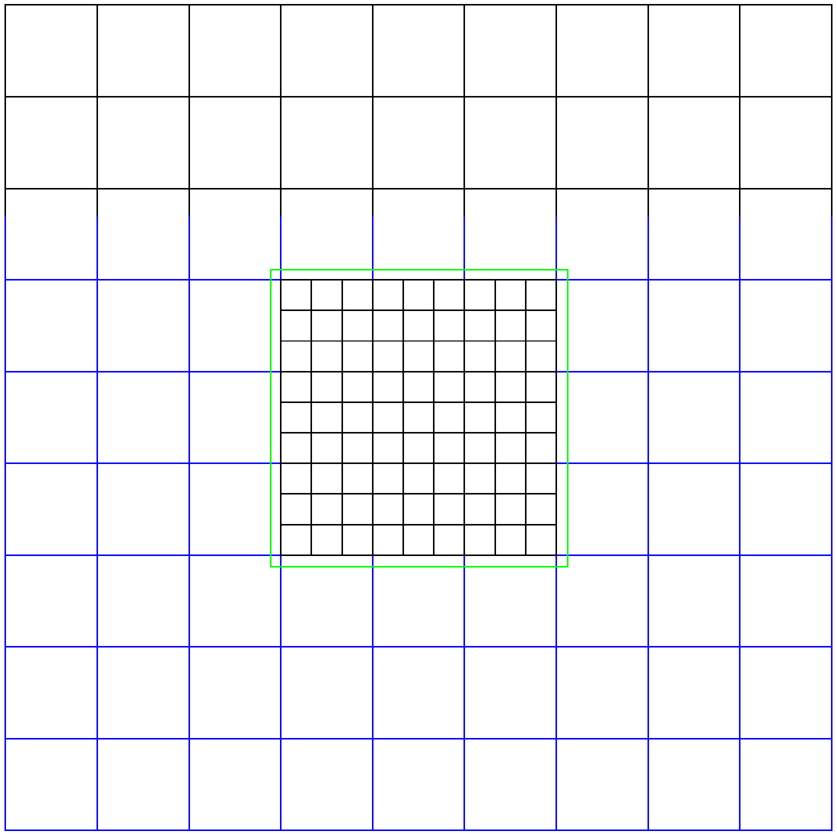


FLOWSTAR

- Use FLOWSTAR (ADMS mean flow and turbulence model) to incorporate effects of
  - Variable terrain height
  - Variable surface roughness
  - Both

- This can be incorporated within the spatially varying meteorology framework with an upstream condition for FLOWSTAR determined from the spatially varying meteorology

Horizontal locations of flow field data for variable terrain embedded within the meso scale meteorology data. The extent of the terrain region is given by the green box.



Results - FLOWSTAR

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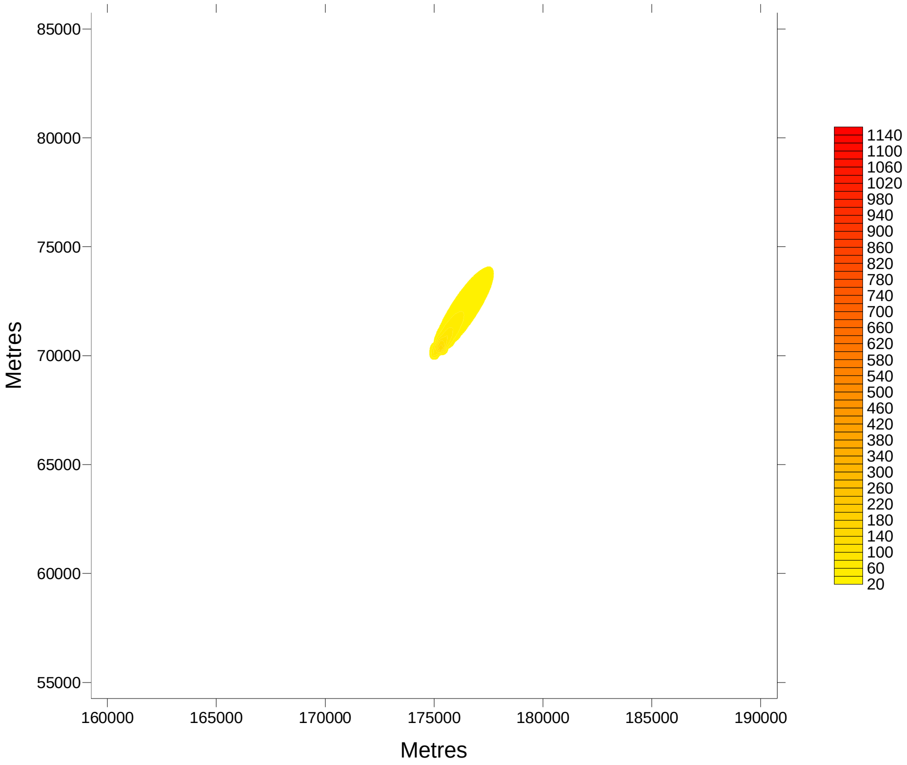
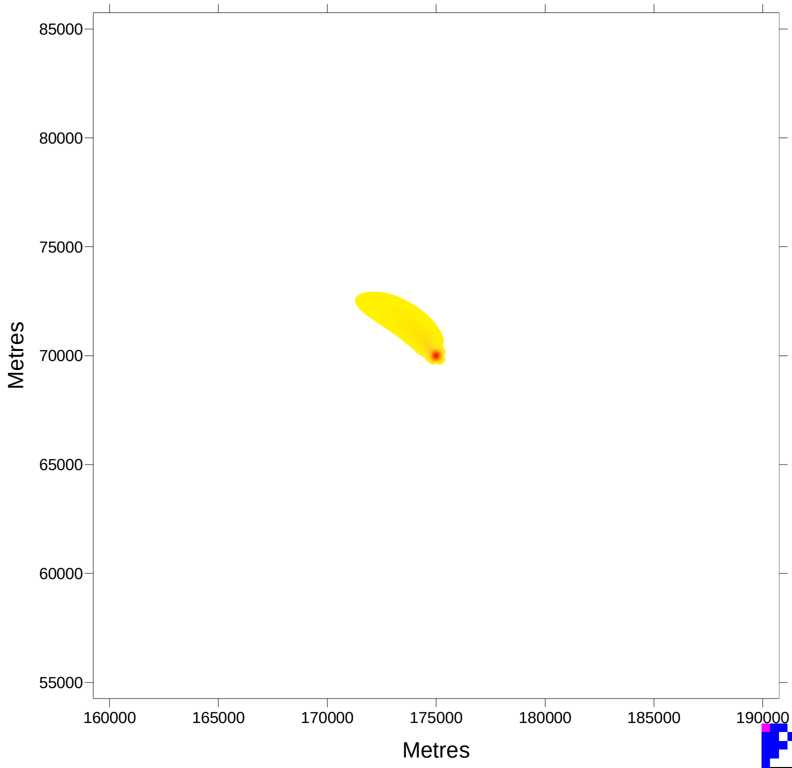
Total deposition for two runs with the same set up and for the same time period, except that one run uses variable terrain height

Without terrain



With terrain



Observed site met data

- With spatially varying meteorology can include site observed values of
  - Wind speed and direction
  - Surface temperature
  - Rain fall rate

- Used to improve calculations near to the source

- Observed site data relaxes over a radius of influence back to the meso scale meteorological data

Results – observed site data

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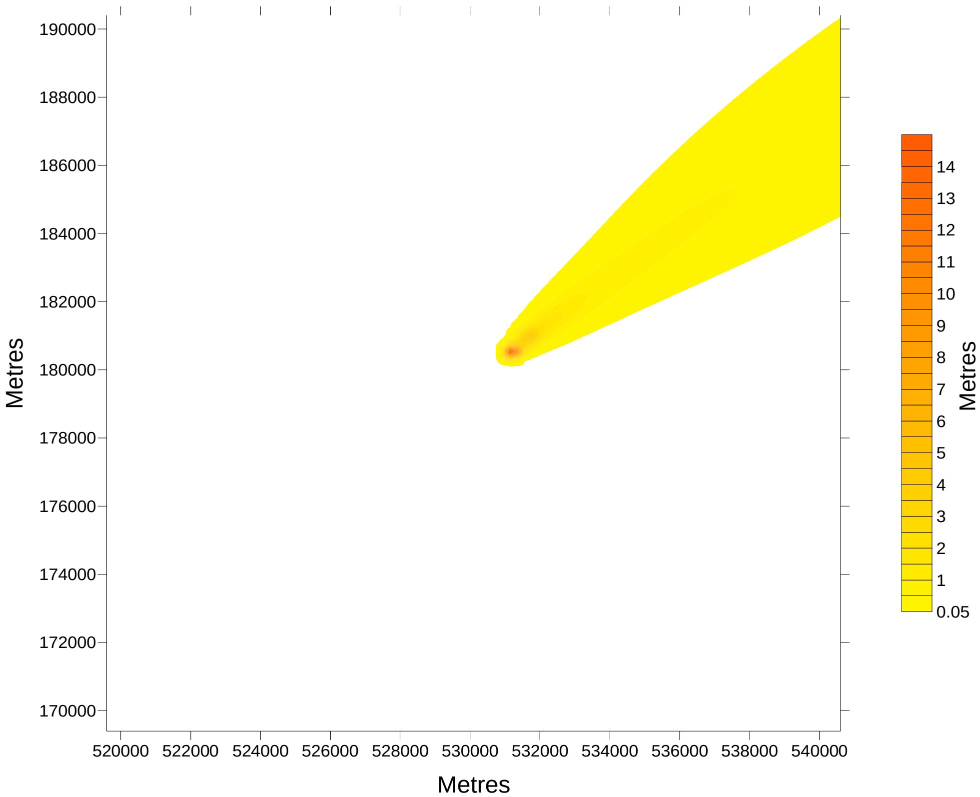
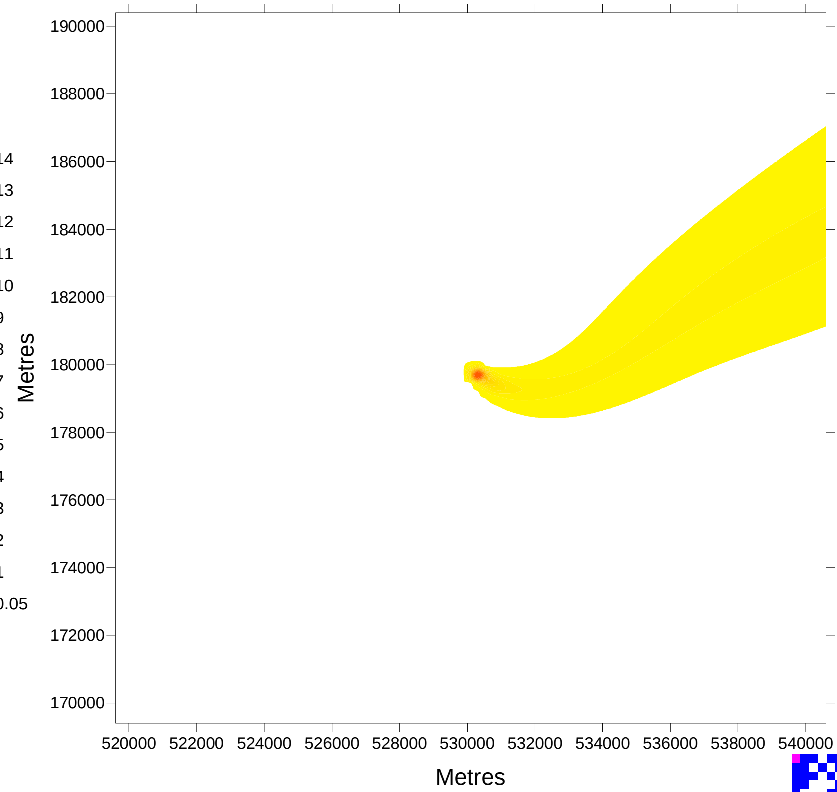
Total deposition for two runs with the same set up and for the same time period, except that one run has site observed data changing the wind speed near the source

No site data



Wind on site 315^{o}



Conclusions

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- Puff dispersion model.
  - Release modelled as a set of instantaneous puffs
  - Individual puffs properties updated based on local, in time and space, meteorological conditions
- Allows short term releases to be modelled in spatially and temporally varying meteorology
- Allows complex terrain to be modelled
- Allows observed meteorological data at the source to be incorporated

- Validation and verification of the model
- Further developments …