VISUALISING THE SPREAD OF ASSESSMENT RESULTS DERIVING FROM UNCERTAINTY IN SOURCE TERM AND DISPERSION MODELLING FOR INPUT TO EARLY HEALTH PROTECTION DECISIONS

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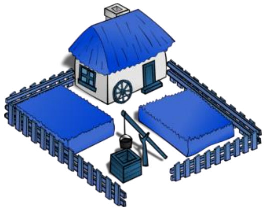
This project has received funding from the Euratom research and training programme 2014-2018 under grant agreement No 662287

In a radiation emergency, early assessments are undertaken to ….

- identify scale of emergency
- identify affected areas (current and predicted)

- inform health protection decisions & emergency actions
- basis for public messaging/reassurance



- begin preparation for possible future actions

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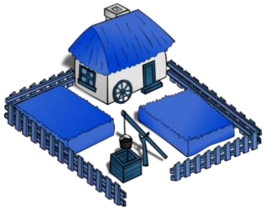

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Early emergency assessments…

- Need rapid decisions to protect health
  - won't have detailed understanding of the situation….
  - …. but decisions on protective actions must be taken despite this

- Need to think about what significant information is not yet known

- Need to balance early estimates of dose against the risks of early emergency actions - in particular the risk associated with evacuation

- So, important to be able to present the uncertainty in dose estimates to decision-makers

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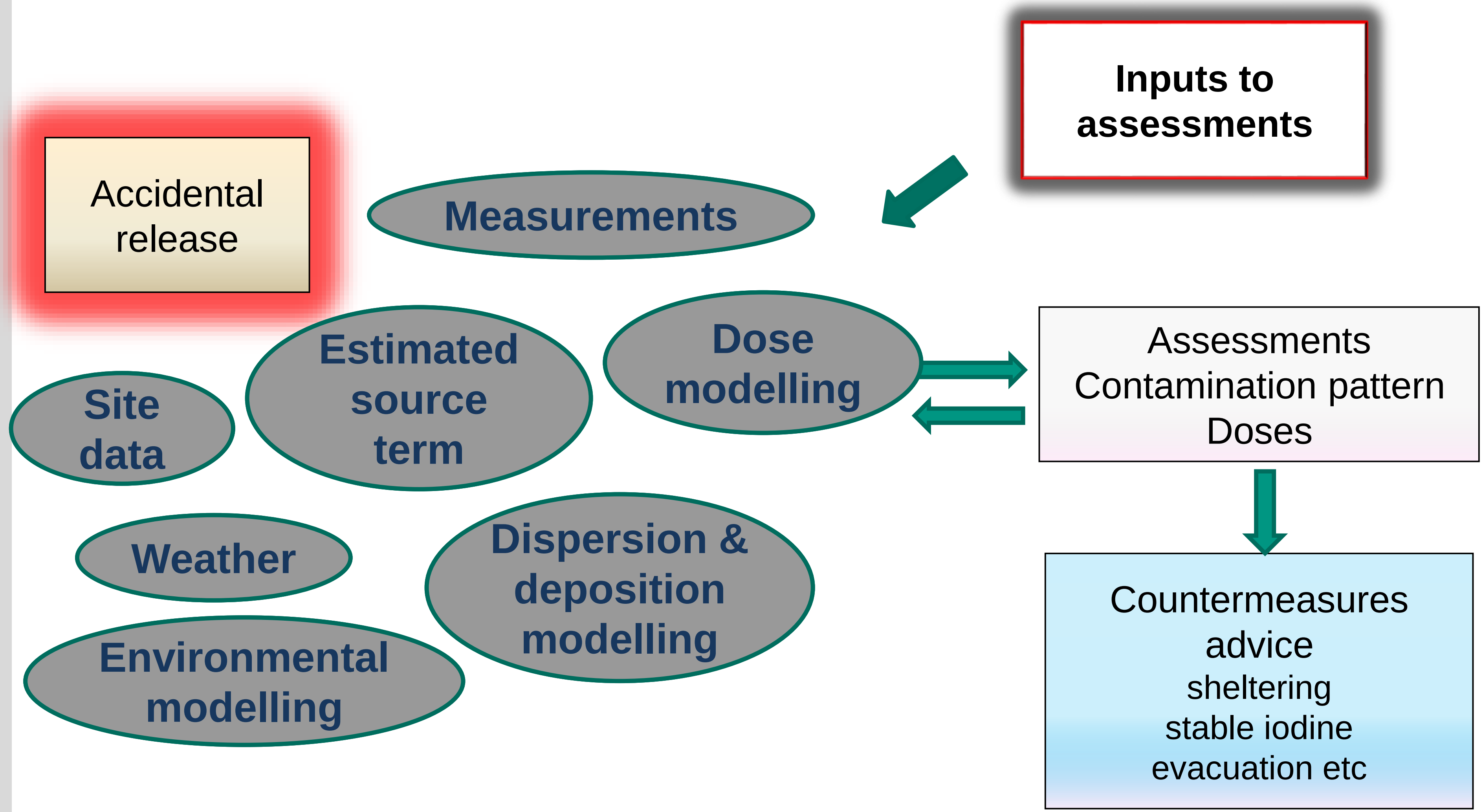
Emergency assessments



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Emergency assessments

Accidental release

Measurements

Site data

Estimated source term

Dose modelling

Weather

Dispersion & deposition modelling

Environmental modelling

All components contain uncertainties, and calculations are approximations

Assessments
Contamination pattern
Doses

Countermeasures advice
sheltering
stable iodine
evacuation etc

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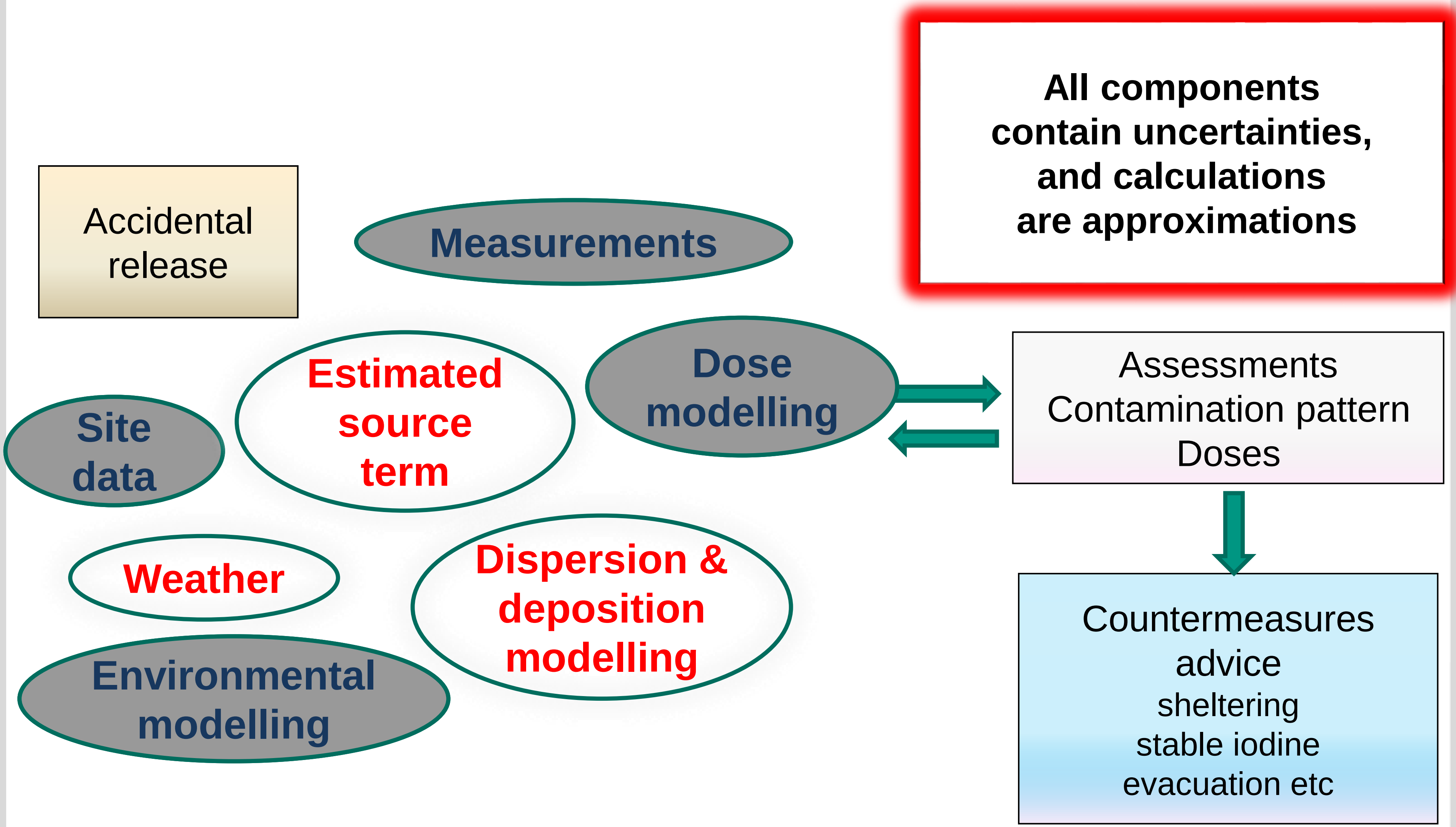
Emergency assessments



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Some causes of uncertainty in source term & weather

- Source term:

  Release start time, fluctuations in release rates, nuclide composition, height of release, energy content, particle size, chemical form

- Weather, and dispersion & deposition modelling

  Wind direction and speed (spatial & temporal), rainfall, atmospheric stability and turbulence

  Dispersion modelling approximations including terrain effects, deposition velocities, wash-out

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CONFIDENCE Work Package 6

- Public Health England (PHE) & the University of Warwick, UK are participating in WP6 of CONFIDENCE

- WP6 concerns decision making under uncertainties:
  - developing approaches to visualise the predictions of emergency assessments showing uncertainty – especially in atmospheric dispersion and source term predictions

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CONFIDENCE Work Package 1

- WP1 is undertaking the propagation of uncertainties through atmospheric dispersion and radiological assessment models

- WP1 has assessed ensemble dispersion simulations performed by WP1 participants for a hypothetical accident scenario at Borssele nuclear power plant (Netherlands)

- Different types of atmospheric dispersion model were used by different participants (Eulerian, Lagrangian particle, puff models)

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Findings from WP1 useful for WP6

- Substantial differences arise in the WP1 ensemble results between participants
  - perhaps from the different types of model used & model uncertainty, rather than the more usually considered parameter uncertainty?

- Important for presenting results to decision-makers - variation due to different types of modelling approaches seldom considered
  - to what extent the models are related to each other?
  - is one type of model preferable to another for this scenario (eg is one model better able to represent a plume from an explosion or fire?)

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Findings from WP1 useful for WP6

- These points are important in determining the confidence which may be placed in the predictions presented to decision makers
  - Eg if several models which are internally similar to each other are used to indicate possible spread due to modelling differences, false confidence may be presented to decision makers
  - Or, widely differing results obtained from one model with high capability for the particular scenario and another with lower capability will suggest model inconsistency which is not applicable to the circumstances

- What is more important? Model uncertainty or uncertainty arising from lack of knowledge? Does this vary with scenario/conditions?

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Work undertaken in the UK

- Warwick University, UK Met Office, PHE are working on an approach for presenting uncertainty to decision-makers

- Particular focus on spatial and temporal uncertainty due to uncertainties in weather (dispersion and deposition)

- 2 workshops of UK government & agencies explored how uncertainty is understood/presented (DH, PHE, Met Office, Cabinet Office, ONR, DECC, DEFRA, FSA, EA, Home Office, MoD, GOScience….)
  - Aim was to develop improved & shared understanding, and realistic expectations from both decision-makers and scientists

*Presenting Uncertain Information in Radiological Emergencies

at https://admlc.wordpress.com/publications/

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Workshop outcomes

- UK decision-makers were keen to see at least a ‘best-estimate’ scenario and a ‘reasonable worst case’ scenario

- Generally, conclusion was that decision-makers should be provided with 3-5 scenarios which together provide an overview of the range of possible impacts that might result from the accidental release

- Presentation of uncertain information needs to be clear (decision-makers unlikely to be specialists)

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Issues for response

- A key factor in ***response*** is computing resource requirements and the time required to produce results

- A full probabilistic assessment with full source term uncertainty and full weather uncertainty probably unachievable with current computing resources within a few hours

- How to show uncertainty **<u>without</u>** full analysis, in rapid time?

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Simplifying results for presentation

- We therefore propose that results are presented to decision makers which represent:

  - A best estimate,
  - A good (optimistic) outcome
  - A few (eg two) pessimistic outcomes, ideally through the consideration of more than one endpoint (for example estimated health effects, areas of land affected by food restrictions, economic impact)
  - A very pessimistic outcome (how bad could things really be?)

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Illustration using WP1 results

- Some of the WP1 results have been applied as examples within WP6 as illustrations of the use of mapping to present information to decision makers
- Figures obtained by UK Met Office predictions of dispersion in combination with PHE's estimate of doses for the WP1 Borssele scenario
- Results are for the dose to the thyroid from inhalation of isotopes of iodine, received over 3 days from the start of the release
- Variations included size of release, start time, and multiple alternative weathers (a large number of alternative figures were produced)

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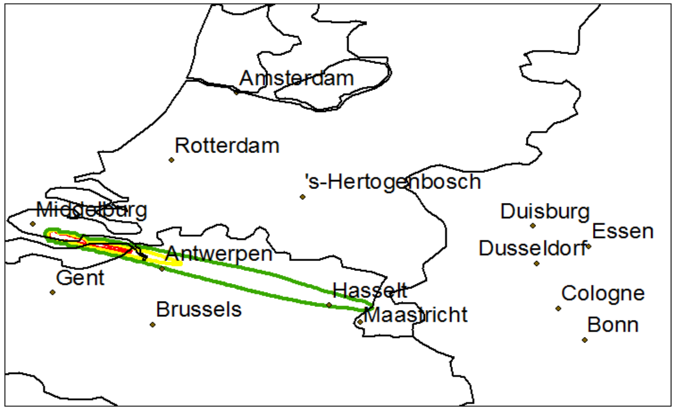
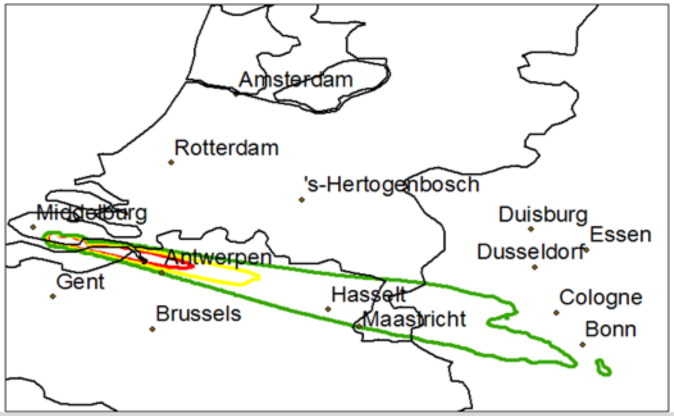


The best estimate source term & mid-start time – an example of the **'best estimate'**

Small estimate source term (1/3 the best estimate) and early start time - an example of a **good (optimistic) outcome**



Large estimate source term (3x the best estimate) & mid-start time - an example of a **pessimistic outcome**

The green contour is the 10 mSv thyroid dose contour, the yellow is 50 mSv, and the red is 100 mSv

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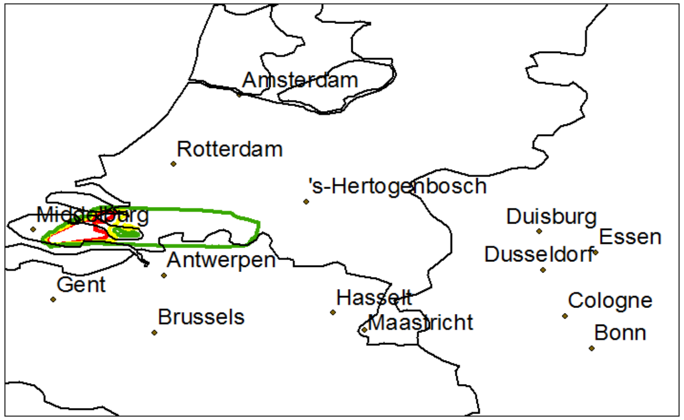
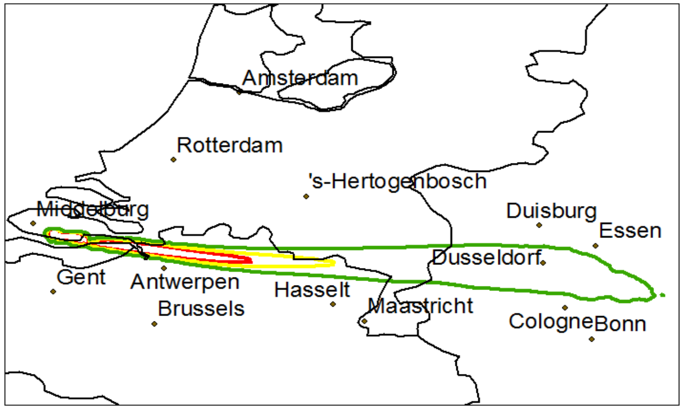


Large estimate source term (3x the best estimate) & early start time - another example of a **pessimistic outcome** (due to the size of the 100 mSv thyroid dose contour)



Large estimate source term (3x the best estimate) & early start time - an example of a **very pessimistic outcome**, due to the extent of the contamination, the inclusion of a major city, and the size of the 100 mSv thyroid dose contour

The green contour is the 10 mSv thyroid dose contour, the yellow is 50 mSv, and the red is 100 mSv

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Practical way forward

- Interim pragmatic proposal:
  - ***best estimate*** can be simply based on calculated results for the series of inputs considered to be the most likely to occur (the most likely weather, the most likely release, the most likely duration etc)
    - This calculation can be repeated as time goes on and the situation changes
  - ***pessimistic endpoints -*** guidelines will be developed on what circumstances typically lead to the greatest consequences, in terms of weather, release, and duration
    - guidelines will be developed for several different circumstances (eg short and long duration particulate release, iodine release)
    - also – what different circumstances maximise consequences for different endpoints (dose/food/protective action distances)

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Summary - practical way forward

- Proposal:
  - In an emergency, several plausible alternatives for source term, weather, and duration will be rapidly developed
  - The ‘maximising parameter guidelines’ will be applied to enable a few (perhaps 3 or 4) combinations from these options to be rapidly assessed

- Such assessments would
  - be quickly achievable
  - and would enable pessimistic consequences to be better understood

- Final stage of the work will be to:
  - to show visualisation techniques for these results, using second set of Borssele runs

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Thank you!