MODULE 2

RASCAL FUNDAMENTALS

This module describes the STDose process, including an overview of the models and methods

SCENARIO

Barakah Unit 1 had been operating at full power.

At 10:00am local time the reactor tripped due to an event causing a major rupture in the primary coolant system (loss-of-coolant accident [LOCA]).

Let's assume that your task is to do a pre-release assessment

Remember to ask: Do you even need RASCAL?

Before you start RASCAL, familiarize yourself with the area, remembering that your goal is protective actions

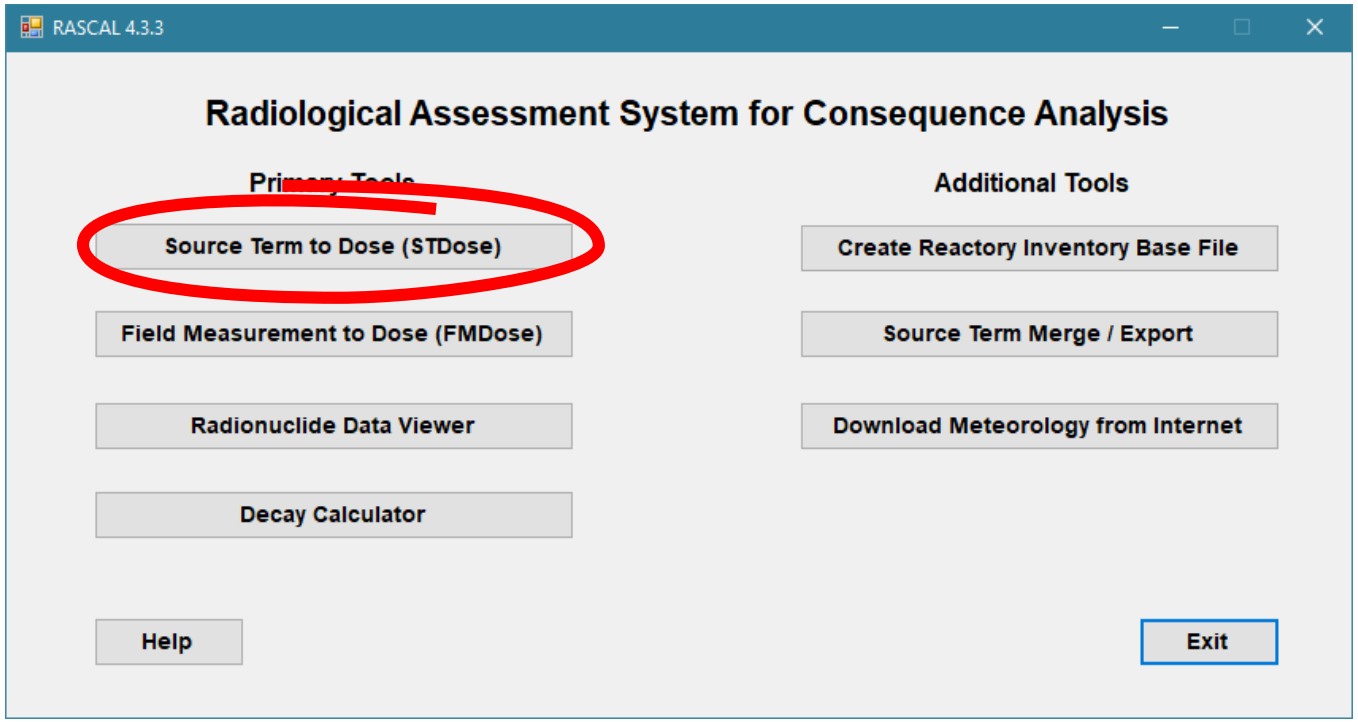
- Water: Is the wind blowing out to sea?
- Population: Any nearby cities or parks?
- Weather: Based on season and location, what weather is likely in that area?

As a RASCAL operator your initial task is to take information and set up a modeling scenario

- Where do you get the information:
  - Plant data systems, communicators, etc.
- Translate available data into RASCAL inputs
  - Some data is “static”; enter once
  - Some data is “dynamic” and changes with time as more communications is established and as conditions evolve

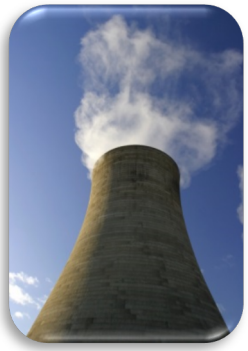
As time progresses, more information is available

WHICH TOOL SHOULD BE USED?

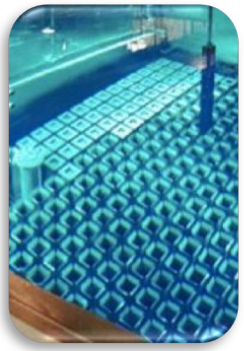


Event Type

START BY CLICKING EVENT TYPE



Nuclear Power Plant



Spent Fuel

Fuel Cycle

Other Material

RASCAL NEEDS TO KNOW WHERE THE RELEASE IS

- Select from a list of predefined sites
  - All US facilities (NPPs, Fuel Cycle, Materials)
  - Some international NPPs including Mexico, South Africa, and the United Arab Emirates
- Or, define a custom site
  - Need Latitude/Longitude coordinates
  - Does not build in roughness or topography

Event Location

Reactor Power

- The reactor power has units of megawatts thermal (MWt) and is a direct measure of the energy produced by fission. This number is used by the model to determine the fission product inventory in the core.
- The facility database contains the power level at which the reactor is allowed to operate.
- Since reactors generally try to operate at 100% power, change this value only if given data that the reactor has been operating for some time (days) at a lower power.

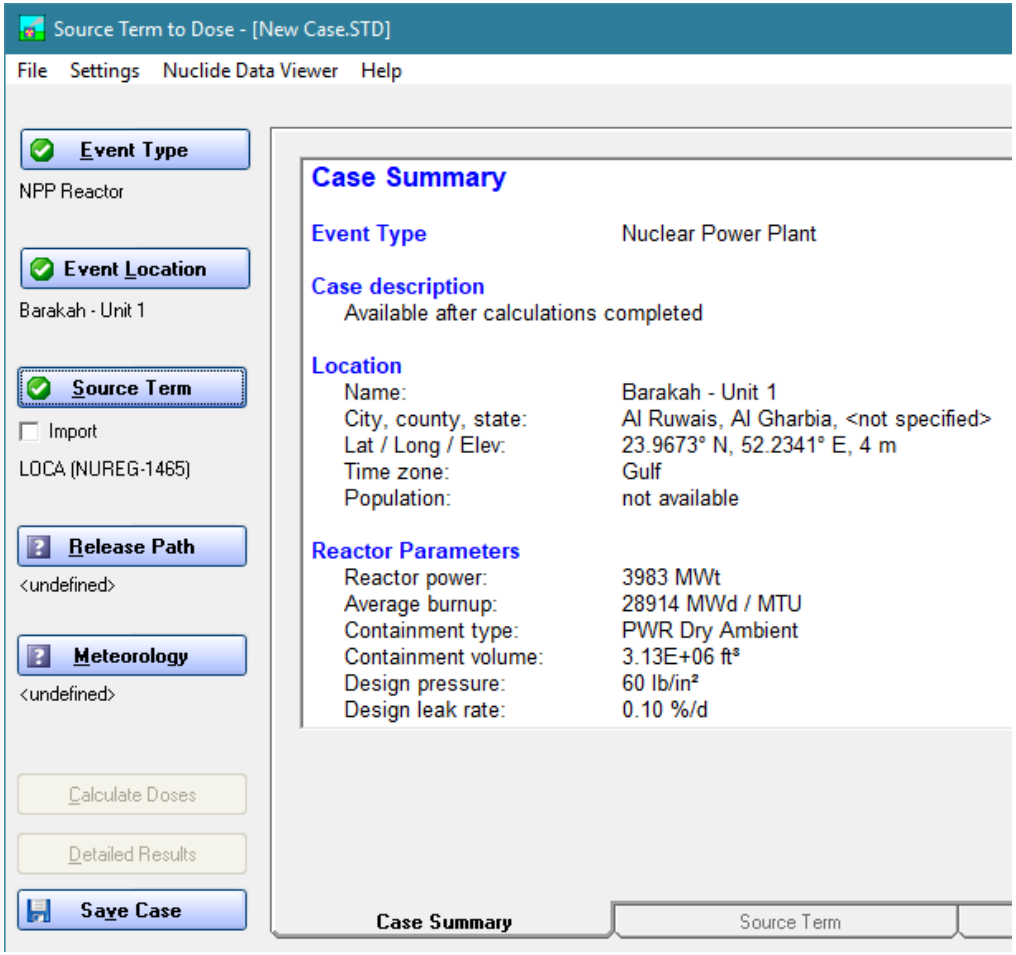
Event Location

BURNUP

- Fuel burnup has units of megawatt-days per metric ton of uranium (MWd/MTU) and is a measure of how much fission energy has been produced by the fuel elements that are currently in the core.
- RASCAL uses burnup to adjust core inventory for long-lived radionuclides in the core fuel. A mid-life core value is used as default instead of site-specific values
- The control room can determine the current fuel burnup, although this will not a have high priority during an actual emergency. If you have a burnup value – use it, otherwise the default is OK.

THE CASE SUMMARY TAB UPDATES AS INFORMATION IS ADDED

As each step is completed, the input information is added to the case summary displayed



Static Information Entered, Now for Additional Dynamic Conditions in Scenario

The licensee believes the core may become uncovered at 13:00 and are unable to activate the containment spray system. They expect the containment to remain intact and any release to the atmosphere will be at the design leak rate.

At 17:00, operators were able to recover the core. Containment remained at high pressure and wasn't reduced until 21:00.

To Calculate the Source Material, RASCAL Will use a Model or Measurement

- Long-term Station Blackout (LTSBO)
- Loss of Coolant Accident (LOCA)
- Coolant Release
- Containment Rad Monitor

Models

- Coolant Sample
- Containment Air
- Effluent Release

Measurements

You'll need to pick the best option with the given scenario information.

Source Term

Each Model Requires Additional Parameters

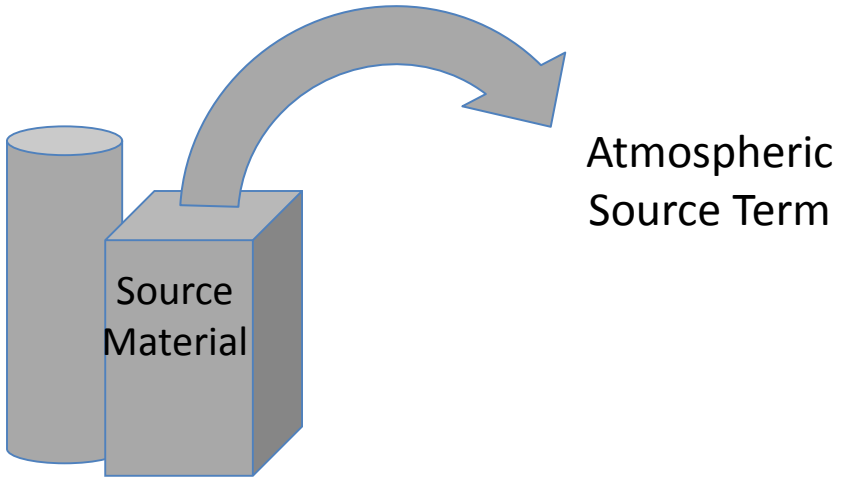
- Timing of key events
- Specific reactor conditions
- Measured data

- Specifically for LOCA, required parameters are:
  - Time of reactor shutdown
  - Time core was uncovered
  - Is the core recovered?

Release Path

RASCAL WILL NEED SOME INFORMATION ON HOW MATERIAL IS RELEASED

- Pathway
  - Determines available release options
- Height
  - Wind speeds change with height
- Reduction
  - Amount of material reduced by decay, holdup, filter, sprays
- Timing
  - Release rates, start and stop

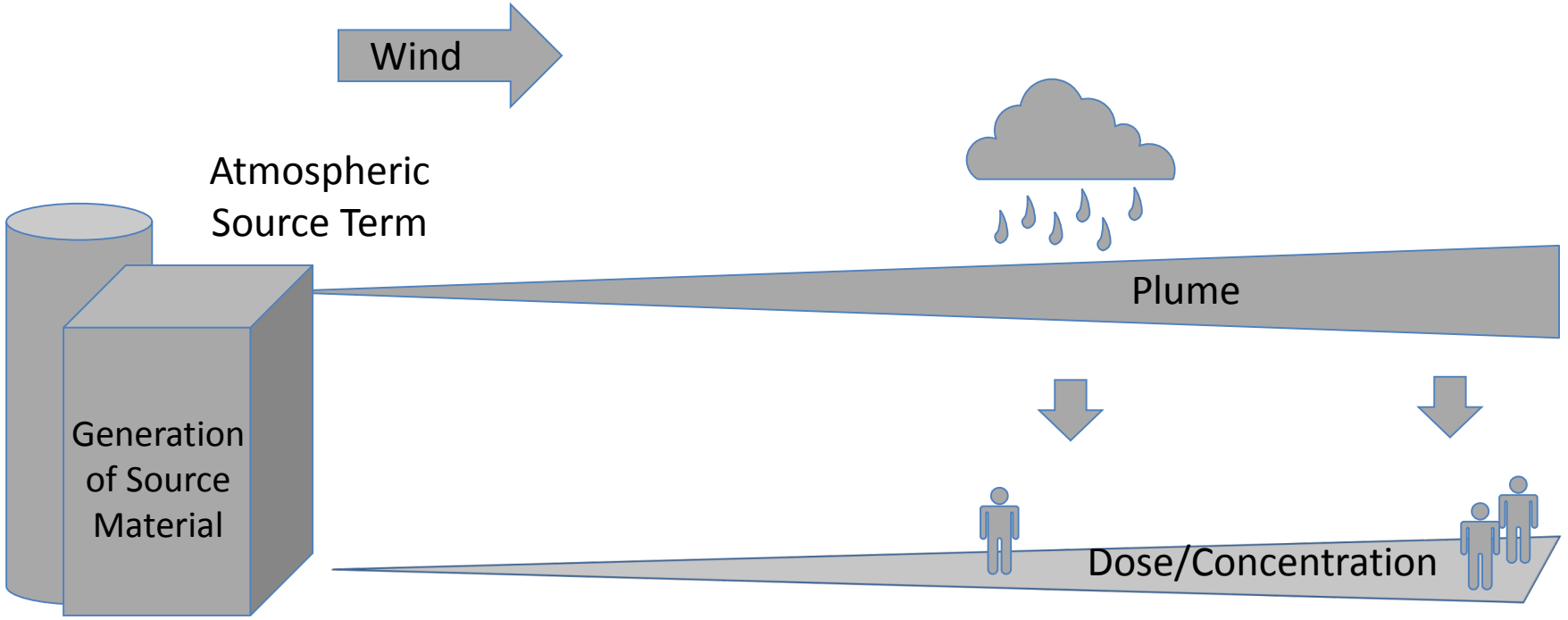


NOW LET'S INPUT THE RELEASE CONDITIONS SPECIFIC TO A LOCA

- Select path of release
  - Containment, Bypass, Steam Generator
- Set height of release
  - 10m is minimum height allowed (ground release)
- Select leak rate type
  - Percent Volume / Time (e.g., 3%/hour)
  - Containment pressure / Hole Size (e.g., 30 psi/2 cm^2)
- Define release timeline
  - Used for leak rate and additional conditions
  - Change when conditions warrant

Meteorology

RASCAL Needs to Transport this Material; Why do we need weather data?



Now for Input of Scenario Weather Data

For this initial run we are going to use weather data such as is usually provided in an exercise – very little, if any, change with time.

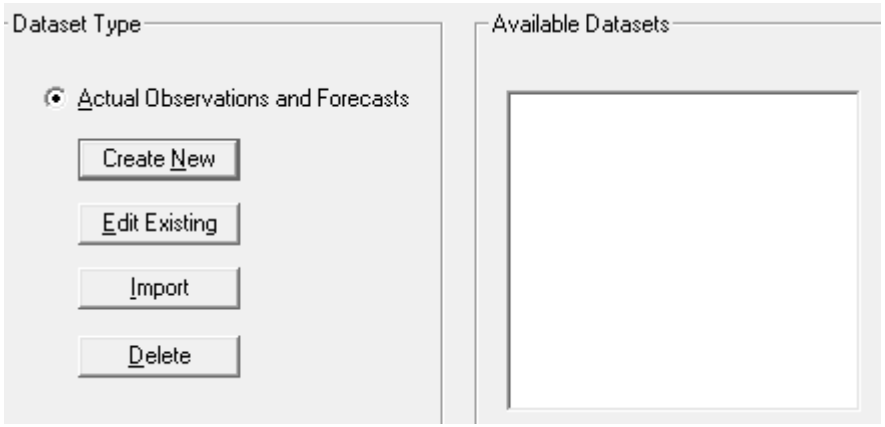
Type	Date	Time	Wind Dir (deg)	Wind Spd (m/s)	Stability Class	Precip	Air Temp (°C)
Obs	Today	12:00	210	3	B	None	11

There are 3 Meteorology Input Options

- Actual
  - Enter station observations/forecasts
  - Manual entry or internet download
- Pre-defined (non site-specific)
  - Simple static weather conditions
  - Easy/fast if no meteorological data known, but doesn't include topo/roughness
- Predefined (site-specific)
  - Allows custom creation of likely conditions

Weather Data is managed as site-dependent files

- Create New / Edit
- View any previously saved weather files
  - Usable as long as times support scenario



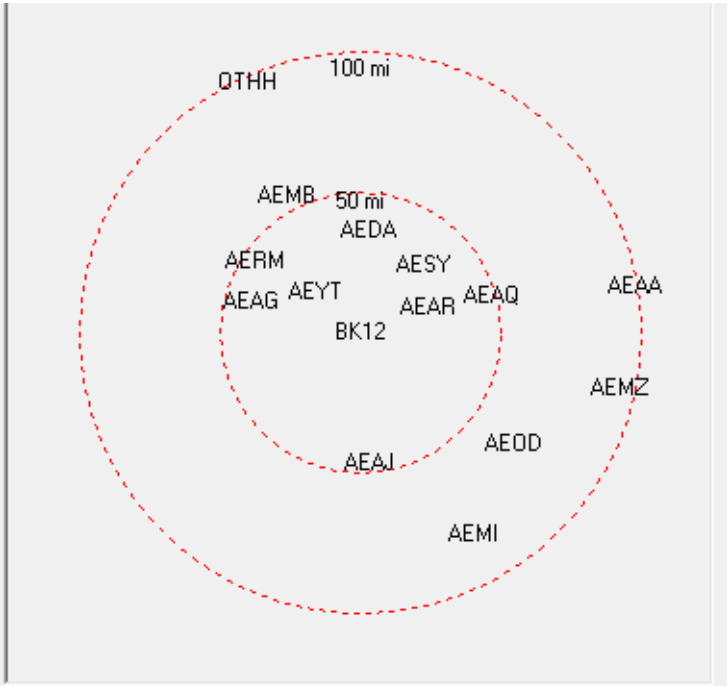
Meteorology

EACH SITE CONTAINS PREDEFINED WEATHER STATIONS

- Table and map show site and surrounding weather stations
- Select stations with plume direction in mind

Available meteorological stations

Station ID	Distance (miles)	Bearing (deg)
BK12	0.0	0.
AEAA	99.5	80.5
AEAG	39.7	285.5
AEAJ	46.8	175.7
AEAQ	48.8	74.6
AEAR	26.0	70.5
AEDA	36.3	5.7
AEMB	54.7	332.
AEMI	82.3	150.5
AEMZ	94.7	102.
AEOD	67.8	125.6
AERM	44.5	304.3
AESY	33.3	43.5

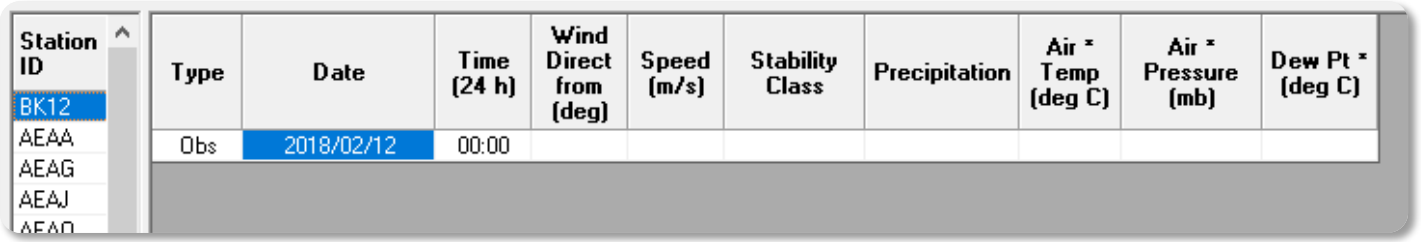


Meteorology

Inputting Weather Data

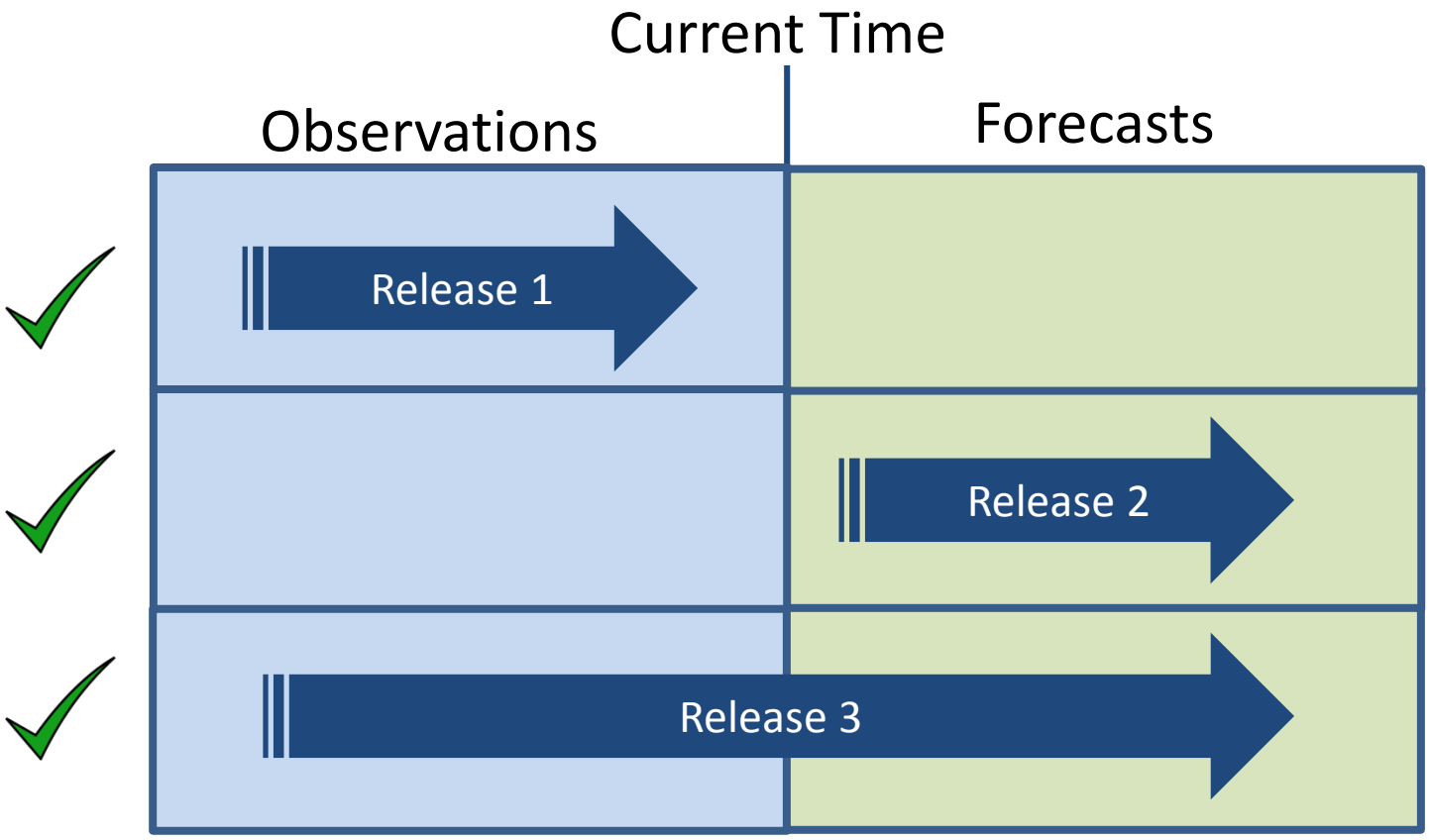
Select weather station on the left to input its data on the right:

- Type
- Date/Time
- Wind Direction/Speed
- Stability
- Precipitation
- Optional Fields (*)



Meteorology

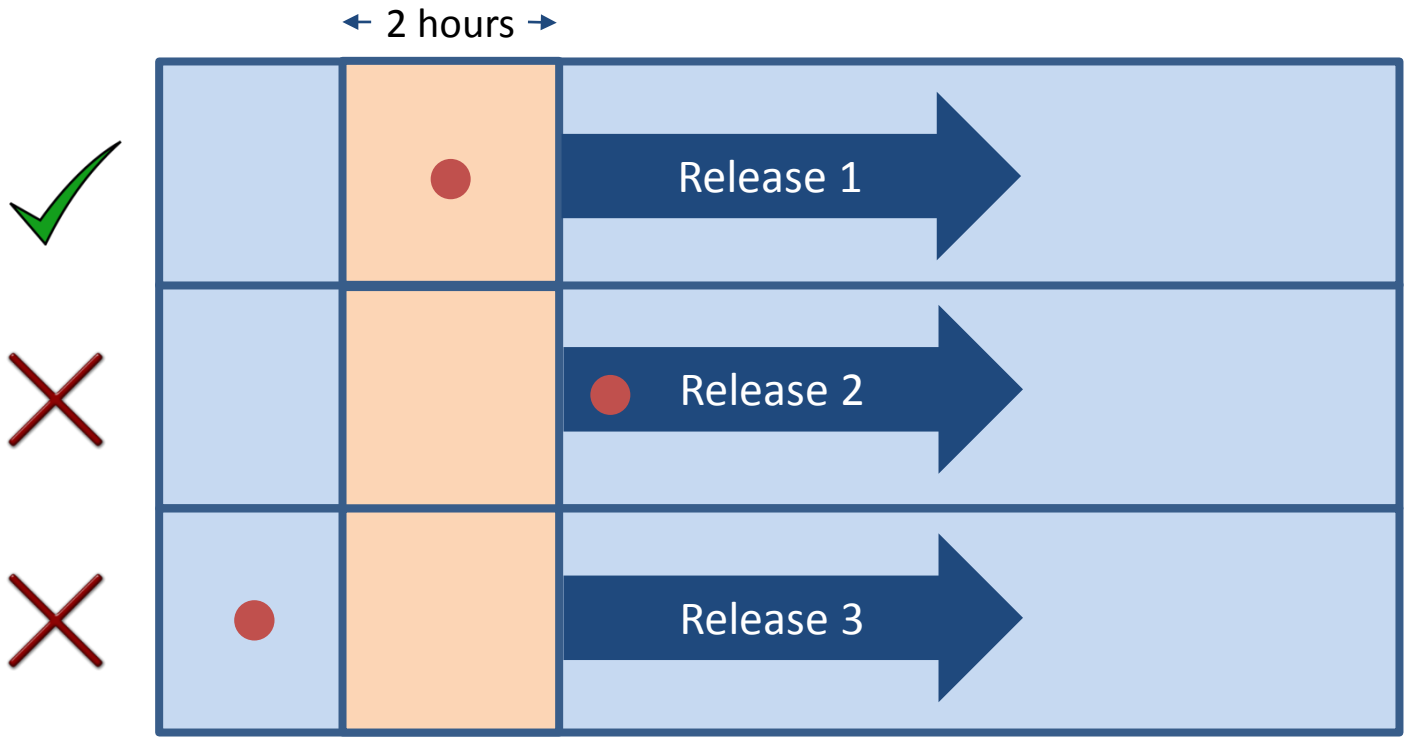
RASCAL USES OBSERVED AND/OR FORECAST WEATHER DATA



RASCAL can model releases in the past (all observations), in the future (all forecasts), or that span both.

Meteorology

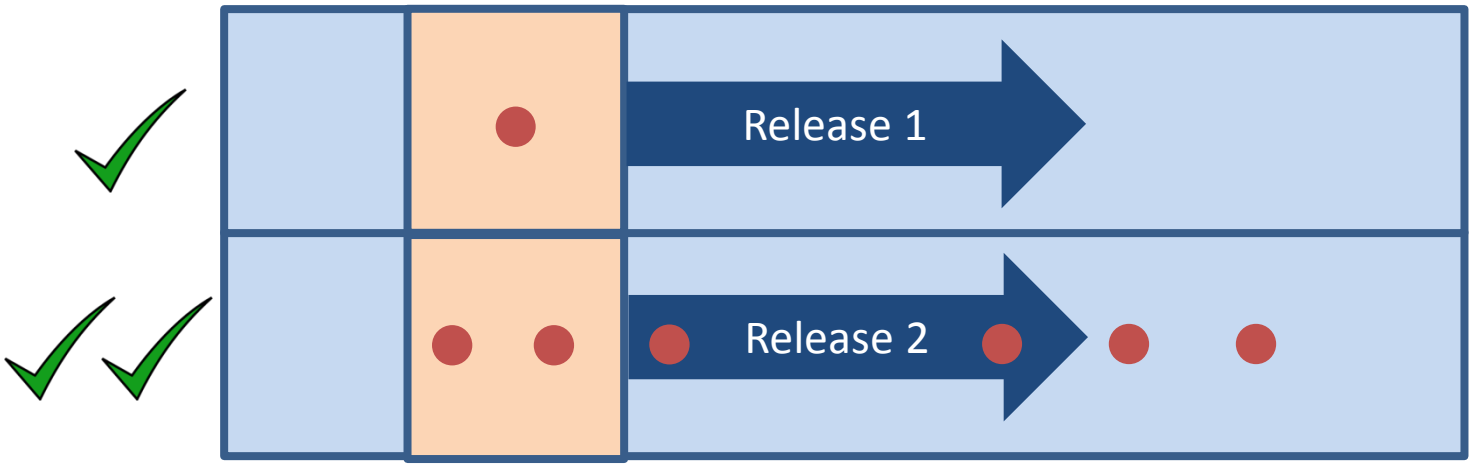
RASCAL Can Run with a Single Weather Datapoint



However, the initial meteorological data must fall within 2 hours before the start of the release to the atmosphere. (Release starts at 13:00; must have some meteorology defined within the 11:00 to 13:00 window)

Meteorology

Although Single Datapoint Weather is possible, More Data is Preferred



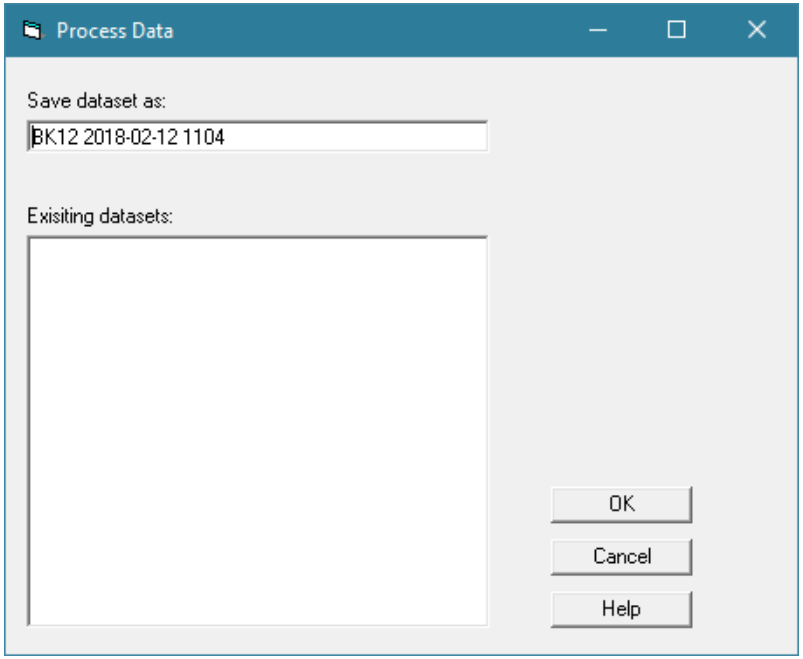
Important when the release may start in the future or may continue for some period of time. You will likely need both observed and forecast data.

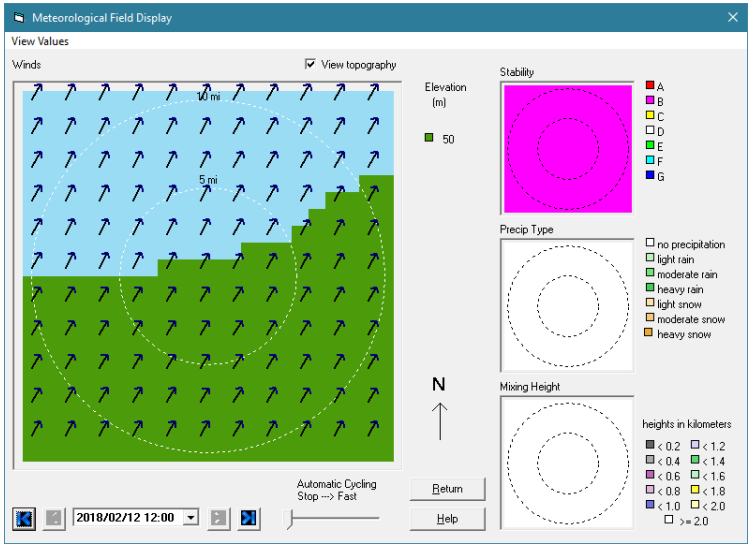
However, our scenario doesn't have additional info like forecasts yet.

Meteorology

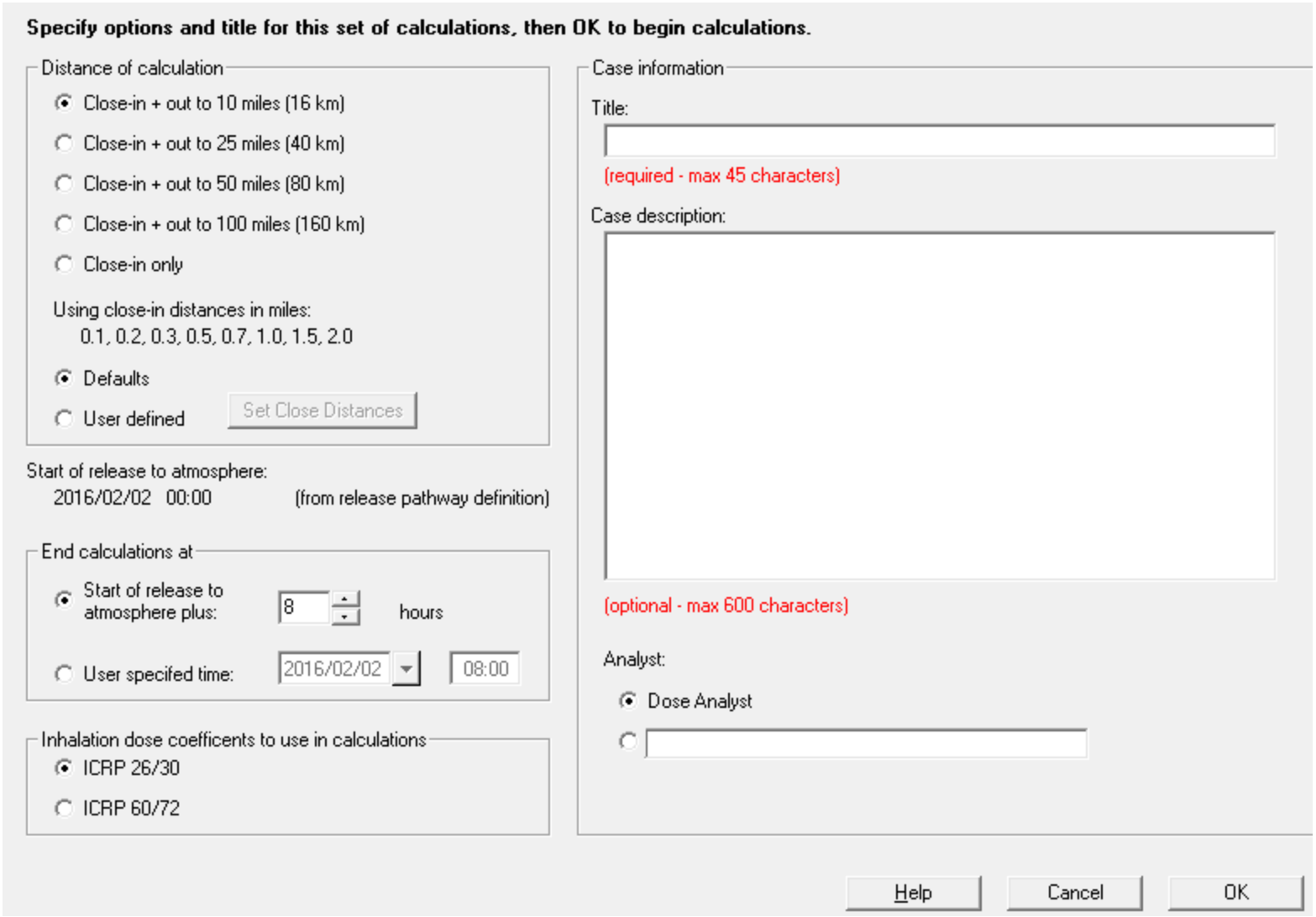
RASCAL PROCESSES ALL ENTERED DATA INTO A MERGED GRIDDED FIELD THAT CHANGES OVER TIME

- This named file will show on the main met screen
- Weather details can be viewed if needed (View dataset)



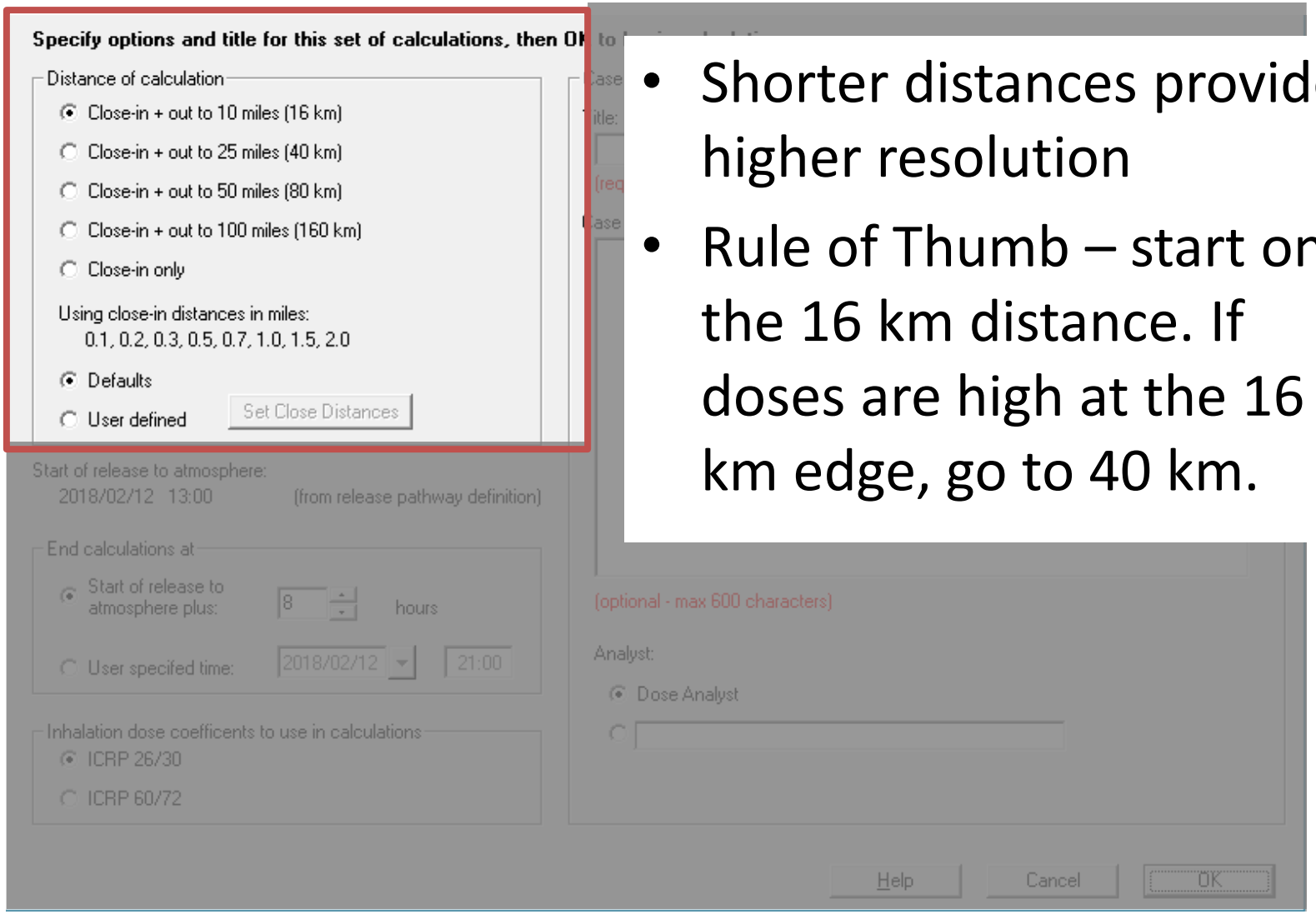


Nothing Has Been Calculated at this point. With a Few Additional Parameters, RASCAL Will Perform All its Calculations



Calculate Doses

PICK A DISTANCE TO SET THE CALCULATION AREA

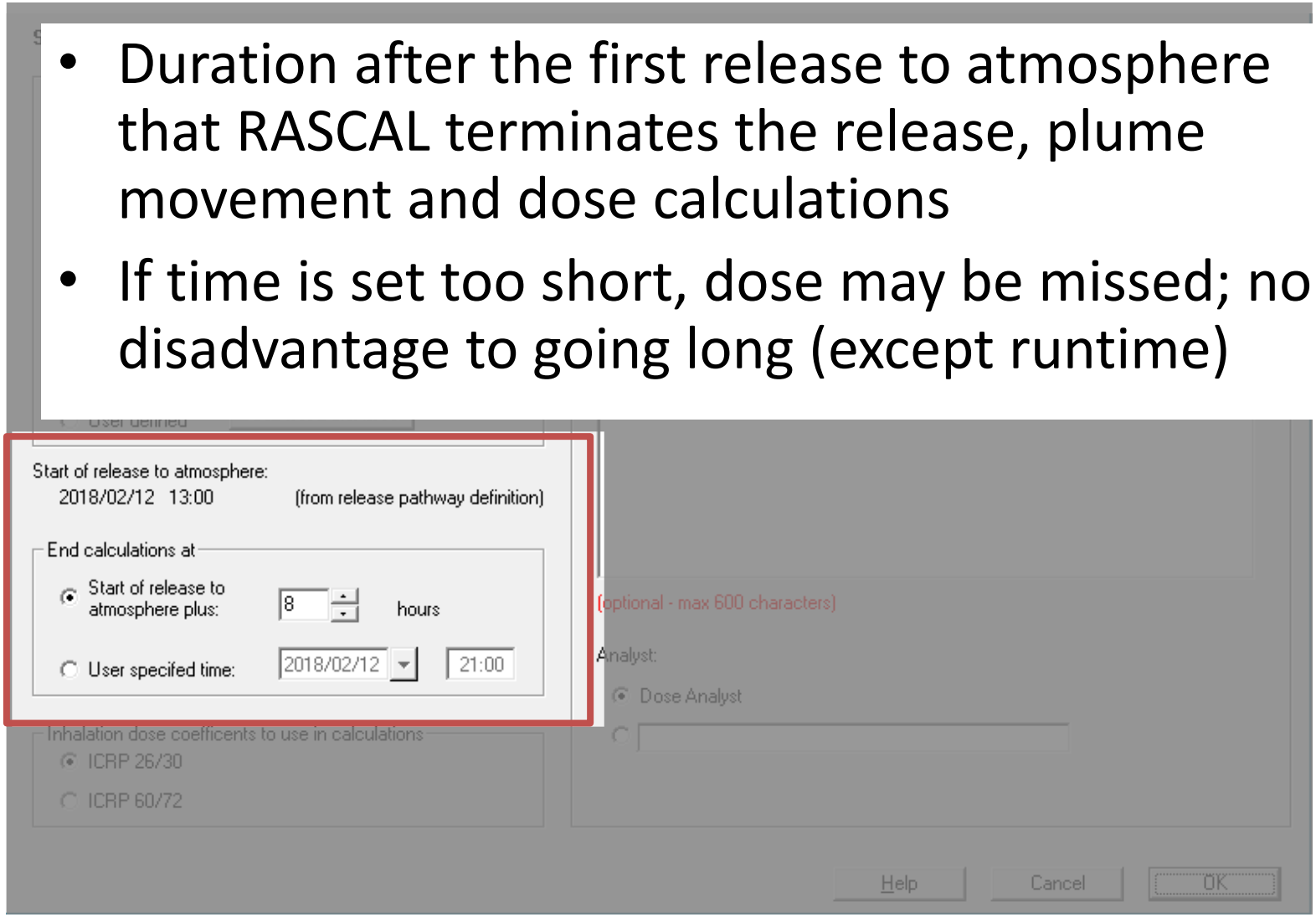


- Shorter distances provide higher resolution
- Rule of Thumb – start on the 16 km distance. If doses are high at the 16 km edge, go to 40 km.

Calculate Doses

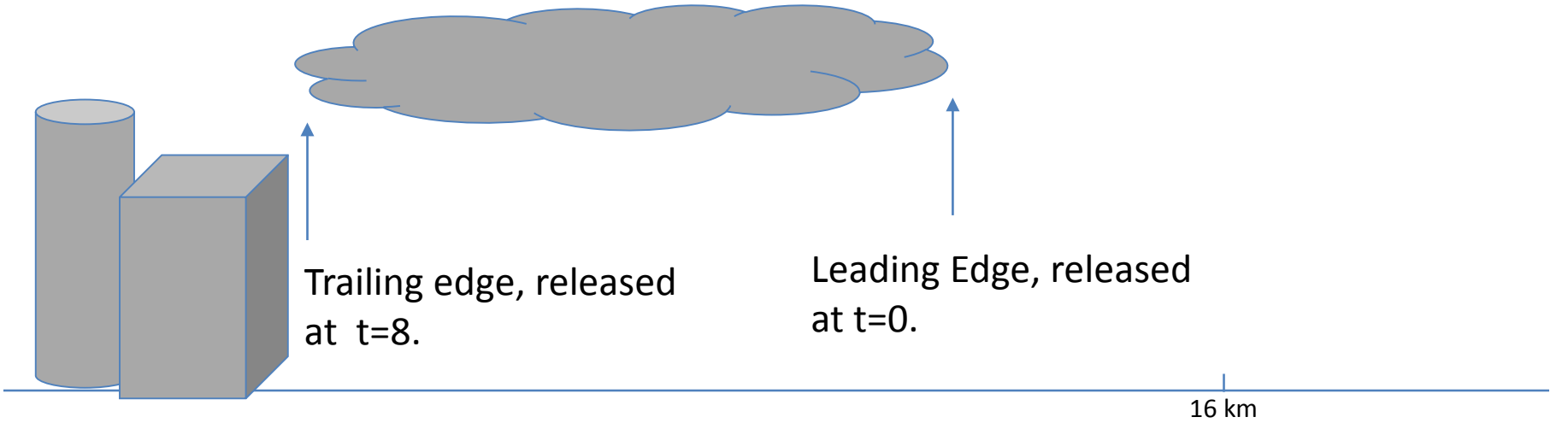
Define a Calculation Time

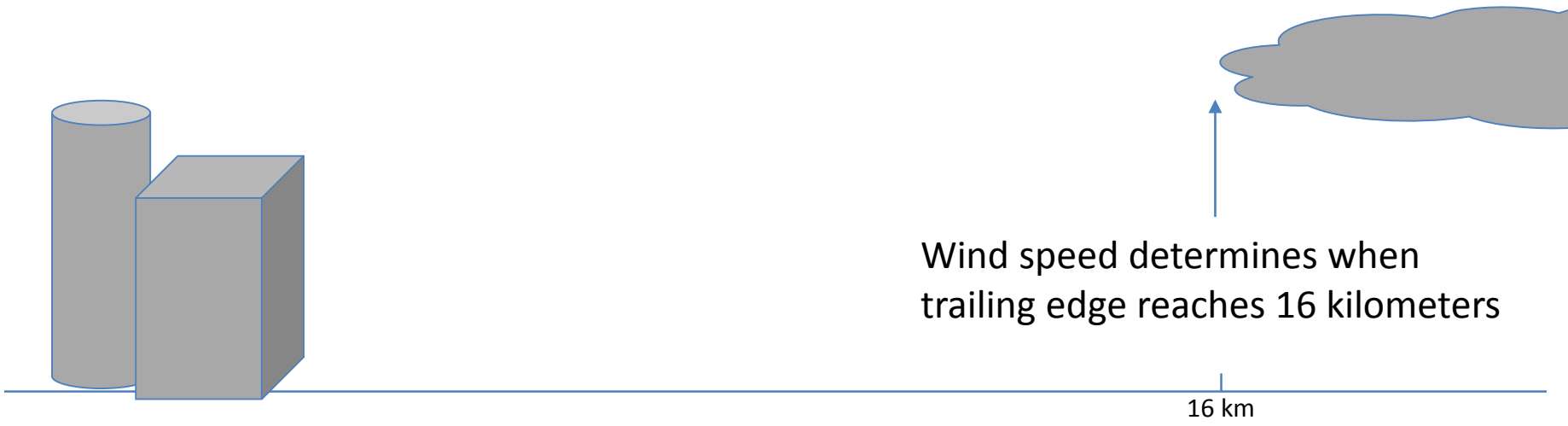
- Duration after the first release to atmosphere that RASCAL terminates the release, plume movement and dose calculations
- If time is set too short, dose may be missed; no disadvantage to going long (except runtime)



Calculate Doses

SET CALCULATION DURATION TO ALLOW FOR TRAILING PLUME EDGE TO REACH SET DISTANCE

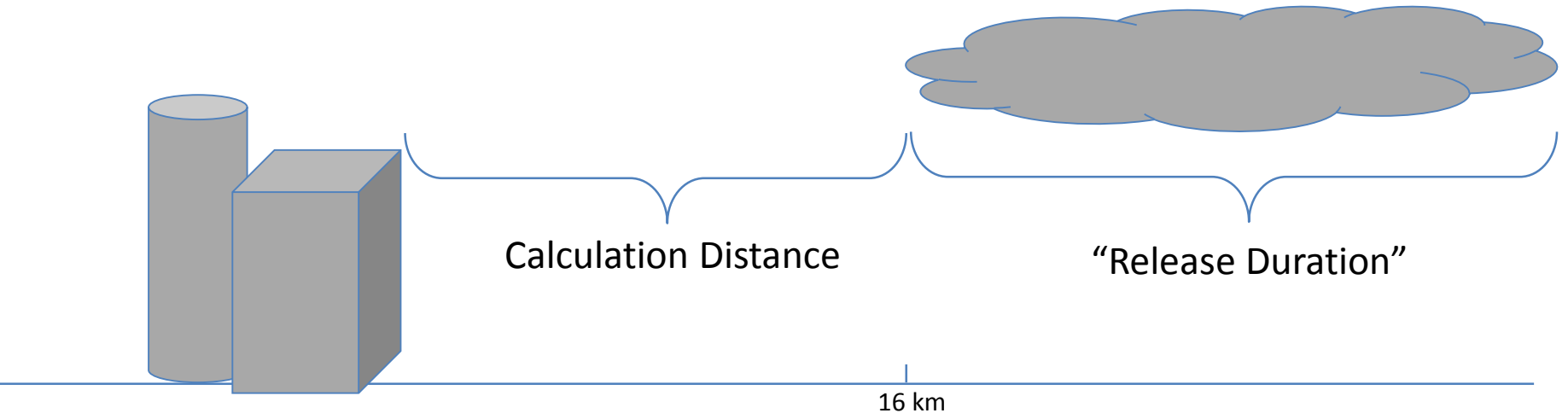




Calculate Doses

THERE IS A RULE-OF-THUMB FOR ESTIMATING THE CALCULATION DURATION

$$Calculation\ Duration \geq \left(Release\ Duration + \frac{Calculation\ Distance}{Wind\ Speed} \right) \times 1.1$$



For a 8 hour release with 3 m/s winds, calculate a duration for 16 km.

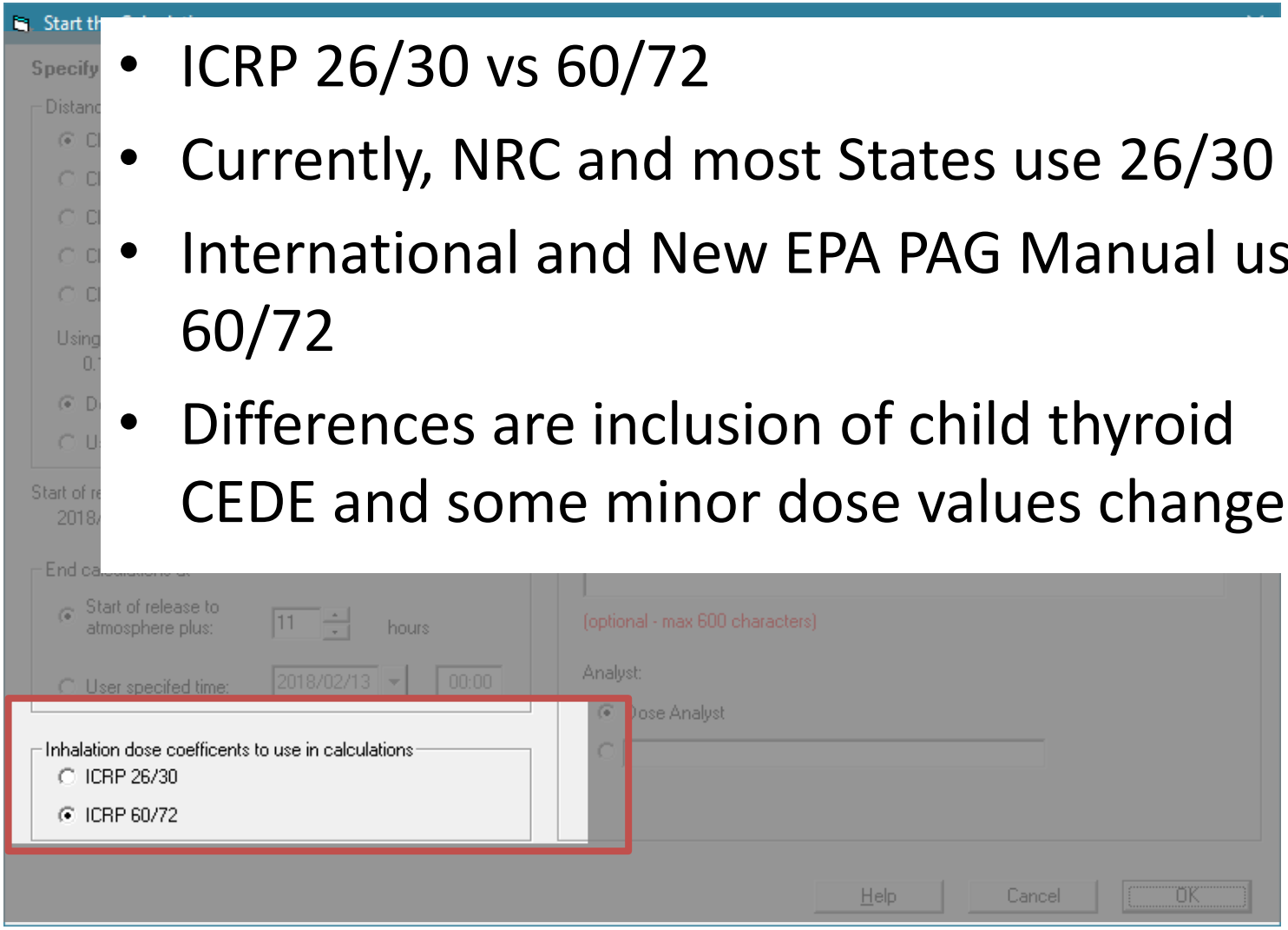
[8h + 16km / (3 * 3.6) km/h] x 1.1 = 10.4; round up to 11h

What if the doses were high at 16 km and you needed to increase to 40 km?

Calculate Doses

SELECT THE INHALATION DOSE COEFFICIENTS TO BE USED

- ICRP 26/30 vs 60/72
- Currently, NRC and most States use 26/30
- International and New EPA PAG Manual uses 60/72
- Differences are inclusion of child thyroid CEDE and some minor dose values changes



ENTER THE CASE INFORMATION

- RASCAL requires a case title
- Description used for justification or special notes; don't need to repeat case info
- Select and/or define an analyst name

Case information

Title:

(required - max 45 characters)

Case description:

(optional - max 600 characters)

Analyst:

Dose Analyst

Help Cancel OK

What happens when the OK button is clicked?

- RASCAL calculates the atmospheric source term and runs the ATD models with the given weather
  - You cannot interrupt the calculations
- Once complete, view results tabs at the bottom
  - Case Summary
  - Source Term
  - Maximum Dose Values

After completing the calculations, save the case

- RASCAL creates a single file
  - Similar to a ZIP file
  - Archives
    - Inputs
    - Results
    - Meteorology data
- Resulting single file can be copied and e-mailed.
- The file can get very large for long calculations.

Source Term Tab Shows Details for Release to Atmosphere

- Summary window
- View Balance
  - Where nuclides are at the end of the simulation
- View Importance
  - What nuclides are contributing the most to dose
- Release vs. Time
  - Displays amount of each nuclide released each 15 minute time step
  - Can be exported

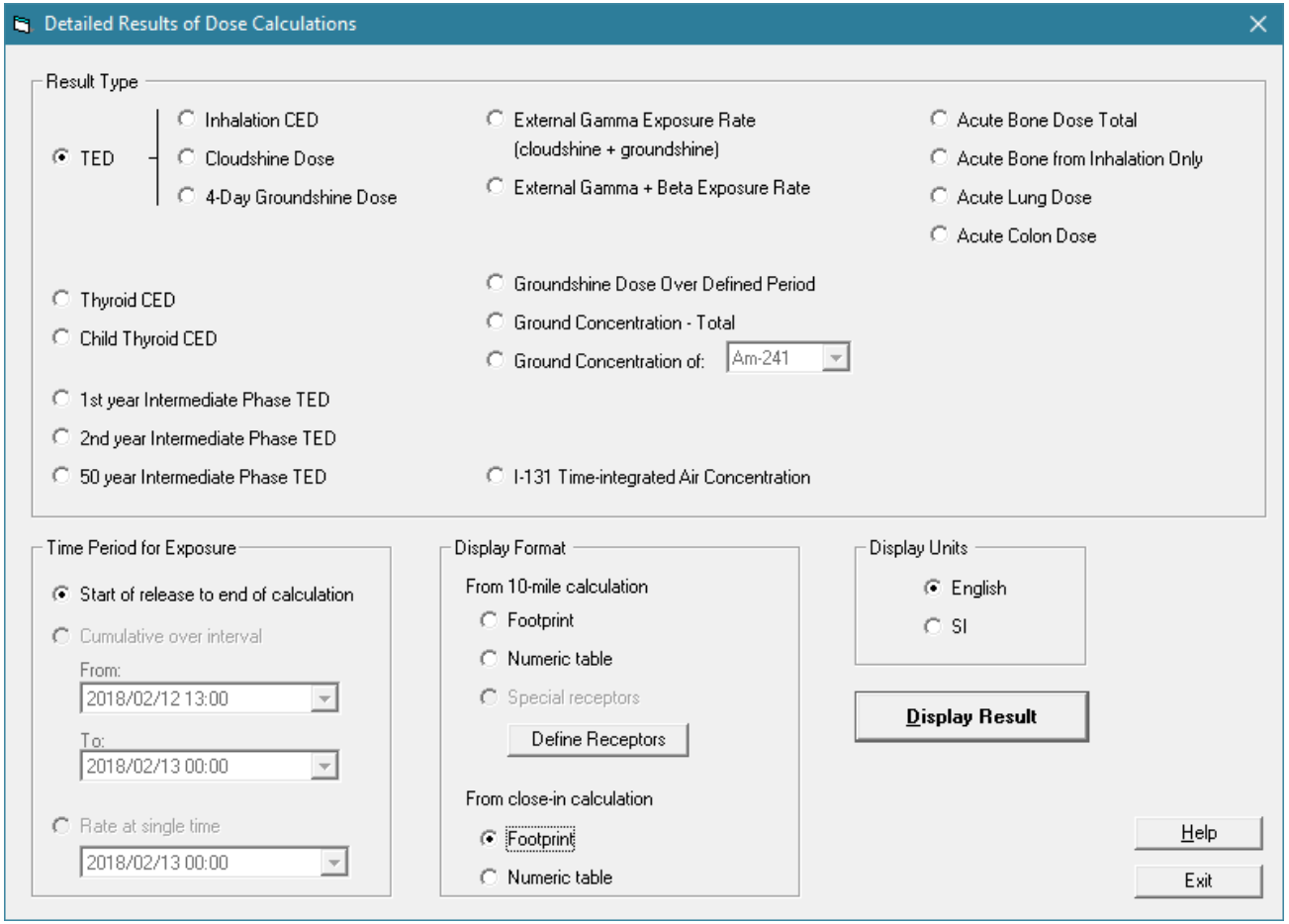
Max Values Table Shows dose snapshot

- Summary window
  - Doses important for protective actions (TED, Child Thyroid CDE)
  - Underlines doses exceeding PAGs
- Select distance
  - Close in vs selected “far out” model distance

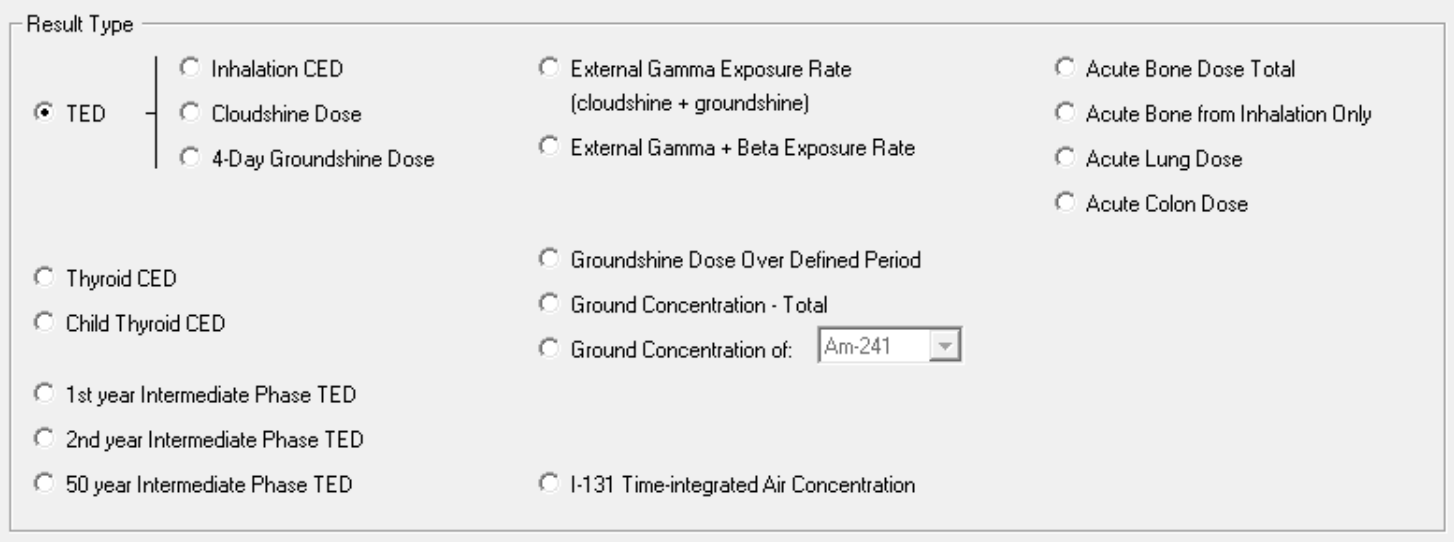
For the doses shown in the max value table, what direction is this from the site?

Detailed Results

DETAILED RESULTS PROVIDE A MULTITUDE OF GRAPHIC AND TABULATED OPTIONS



Detailed Results provide a multitude of graphic and tabulated options

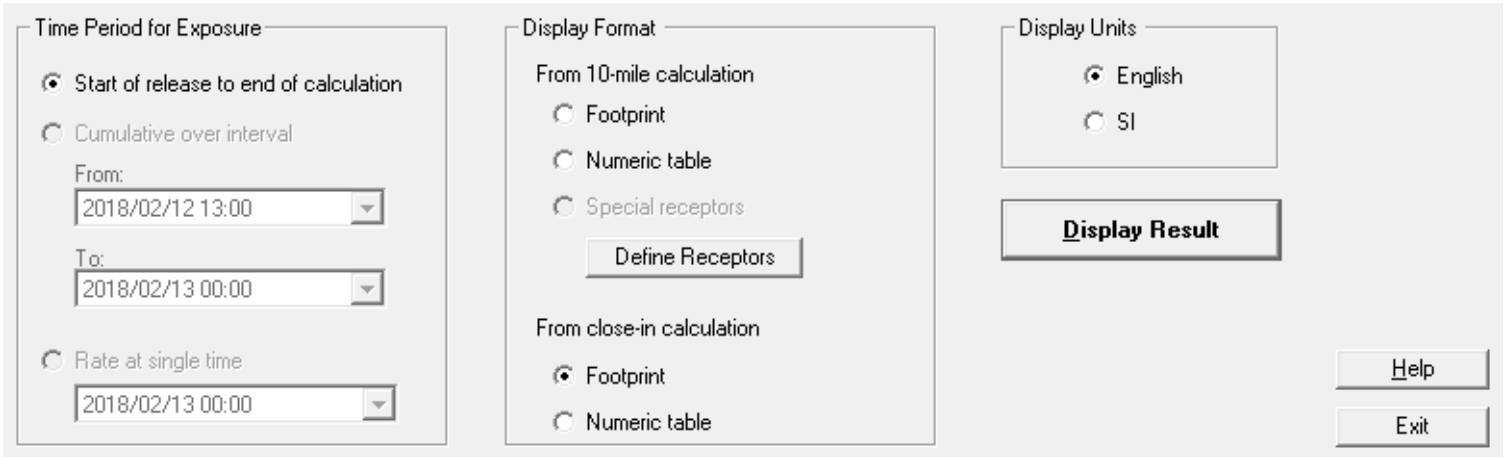


Select a result type to be displayed:

- Dose options on left
- Measurement options in middle
- Acute options on right

Detailed Results provide a multitude of graphic and tabulated options

- Time can be set to be cumulative or at a rate
- Select between graphical footprint and tabular format for close-in or far-out distances
- Lastly, select units

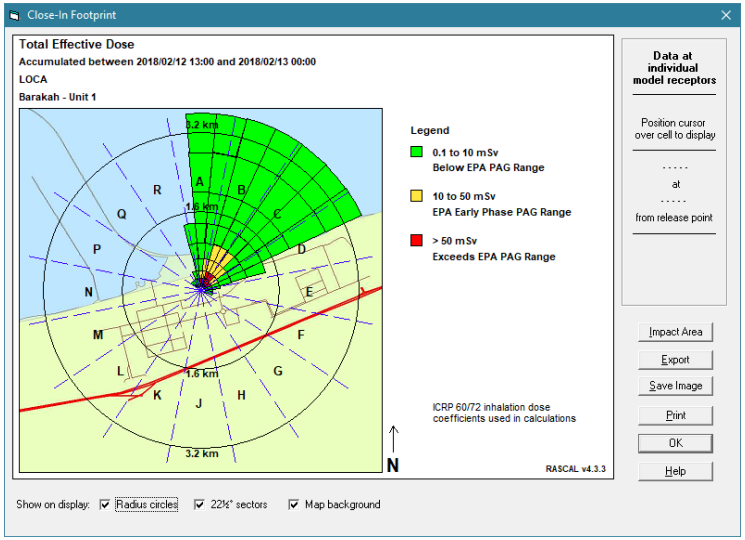


Difference between Footprint and Table

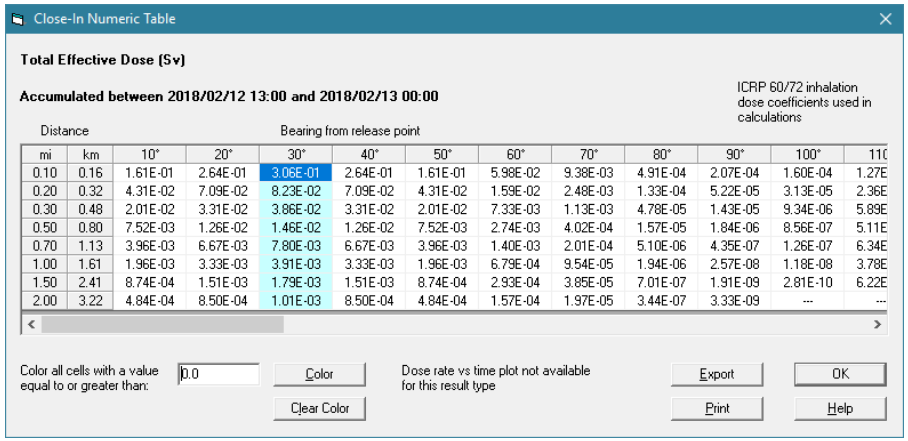
Footprint provides celled results on map

Table provides numeric values

Both can be exported, map can be queried, table can be filtered



Footprint

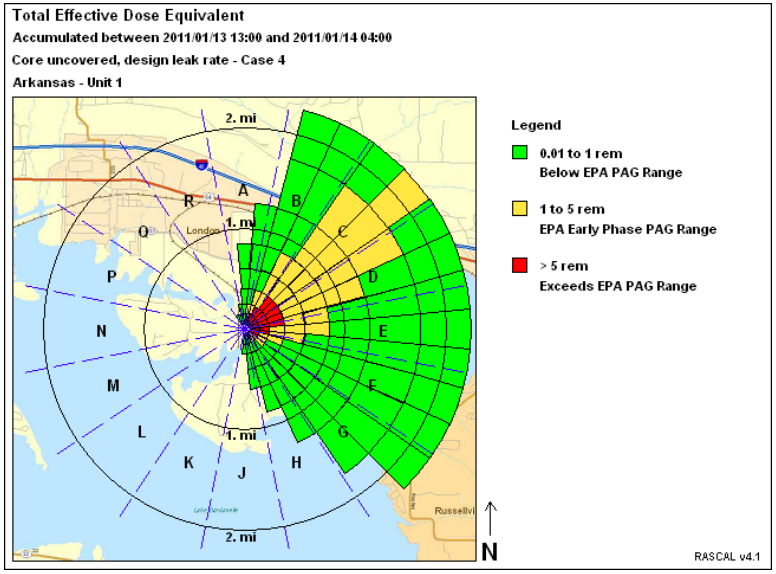


Table

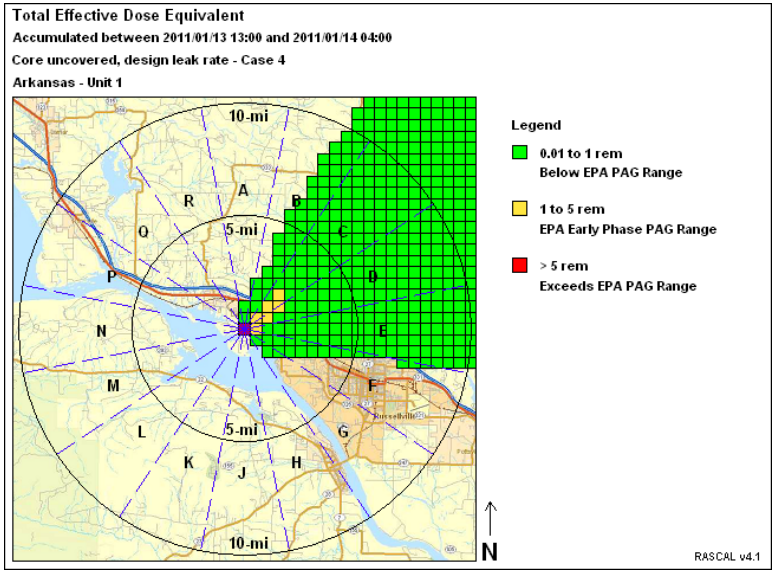
DIFFERENCE BETWEEN "CLOSE IN" AND "FAR OUT"

Two ATD models are used in the calculations

- Resolution advantages
- Overlap may not line up exactly



Plume Model



Puff Model

Problem Task

What is the TEDE and Child Thyroid CDE at 0.32 and at 6.4 kilometers?

	Dose at 0.32 km	Dose at 6.4 km
TED (Sv)		
Child Thyroid CED (Sv)		

Problem Conclusion

	Dose at 0.32 km	Dose at 6.4 km
TED (Sv)	8.2E-02	5.4E-04
Child Thyroid CED (Sv)	1.1E+00	8.5E-03

Uncertainty in:

- Source term – extent and timing of core damage
- Release path – leak rate, reductions, etc
- Met – uncertainty in forecast and in spatial components
- Deposition processes – dry and wet
- People – breathing, moving, sheltering, etc.

A FEW OF THE STDOSE PARAMETERS CAN HAVE DEFAULTS SET THROUGH THE SETTINGS MENU