

# MeIMACCS – Converting MELCOR Output to MACCS Input

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# MeIMACCS

- Post-processing MELCOR accident progression results for MACCS consequence analysis calculations
- MACCS considers plume segments
  - e.g., release fractions for chemical groups per plume segments
- MACCS typically considers 9 chemical classes
  - Equivalent to first 9 MELCOR chemical classes
  - MeIMACCS combines CsI (Class 16) and CsMoO<sub>4</sub> (Class 17) into Cs (Class 2), I (Class 4), and Mo (Class 7) using mass fractions
- This comparison is based on MeIMACCS 2.0.1

NOTE: This presentation will attempt to focus on information passed between MELCOR analysis to the MACCS analysis

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# Radionuclide Inventory

- SCALE-ORIGEN used to generate radionuclide mass, activity, and decay heat
- MELCOR needs radionuclide mass and decay heat
  - Radionuclide results are combined into chemical classes
- MACCS needs radionuclide mass and activity results
  - Radionuclides are mapped to the chemical classes
- MelMACCS Inventory file
  - Used to generate activities for MACCS
  - Inventory files have three groups of radionuclides
    - FISSION, ACTIVATION, ACTINIDE
    - Provide radionuclide masses and activities for each group
- Sum of radionuclide masses in the inventory file within a chemical class must equal the MELCOR class mass
  - MelMACCS scales results to match MELCOR class mass

# Release Flowpath Characteristics

- User defines characteristics of each flowpath to the environment
  - Building Height
  - $\sigma_y$  (SigmaY-Initial)
  - $\sigma_z$  (SigmaZ-Initial)
- Flowpaths are defined by the MELCOR analyst
  - Must confirm building characteristics at release point

MELMACCS 2.0.1 SVN 3177

For each MELCOR release path, enter associated building height for wake calculations. SigmaY relates to initial plume width, SigmaZ to initial plume height.

Reset

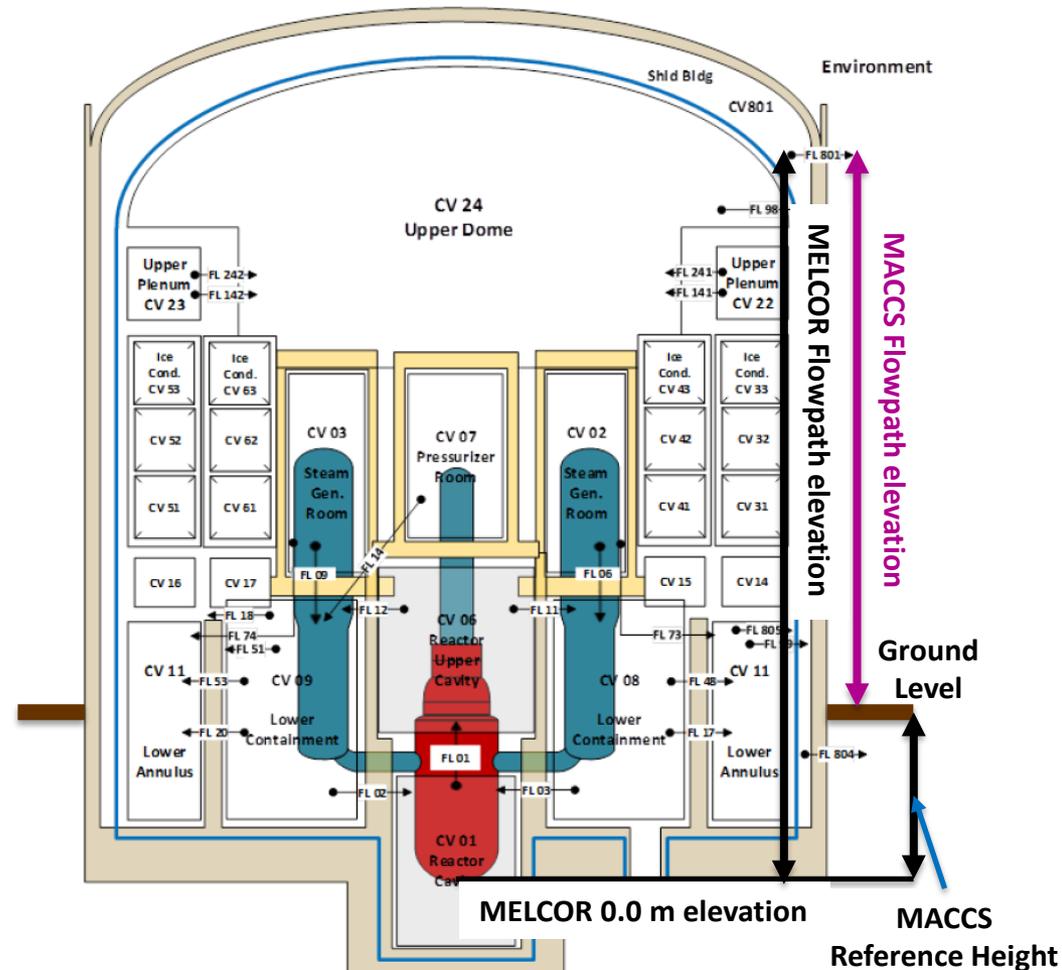
| Release Path | Release Path Height (m) | Adjusted Release Height (m) | Building Height (m) | Initial SigmaY (m) | Initial SigmaZ (m) |
|--------------|-------------------------|-----------------------------|---------------------|--------------------|--------------------|
| 1            | 51.07                   | 39.67                       | 47.2                | 9.4                | 22.2               |
| 2            | 6.876                   | 0                           | 47.2                | 9.4                | 22.2               |
| 3            | 12.7686                 | 1.3686                      | 47.2                | 9.4                | 22.2               |
| 4            | 12.7686                 | 1.3686                      | 47.2                | 9.4                | 22.2               |
| 5            | 12.7686                 | 1.3686                      | 47.2                | 9.4                | 22.2               |
| 6            | 12.7686                 | 1.3686                      | 47.2                | 9.4                | 22.2               |
| 7            | 12.7686                 | 1.3686                      | 47.2                | 9.4                | 22.2               |
| 8            | 12.7686                 | 1.3686                      | 47.2                | 9.4                | 22.2               |
| 9            | 12.7686                 | 1.3686                      | 47.2                | 9.4                | 22.2               |
| 10           | 12.7686                 | 1.3686                      | 47.2                | 9.4                | 22.2               |
| 13           | 12.7685                 | 1.3685                      | 47.2                | 9.4                | 22.2               |
| 14           | 12.7685                 | 1.3685                      | 47.2                | 9.4                | 22.2               |

Auto Fill

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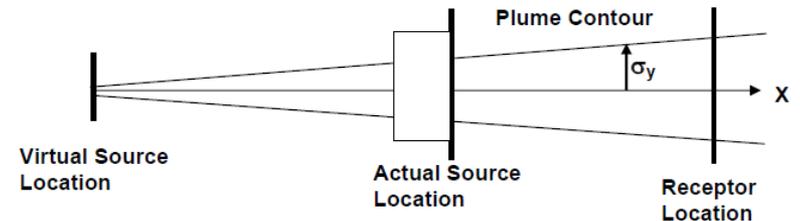
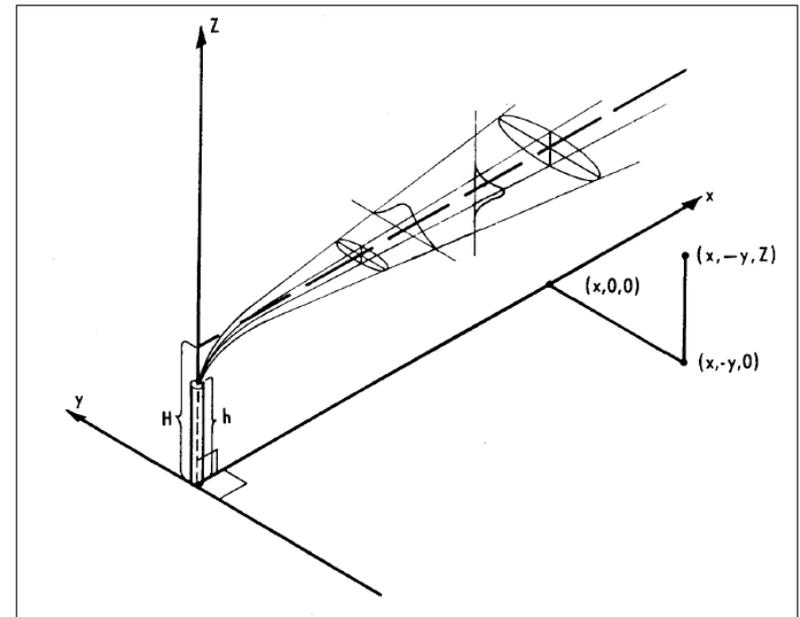
# Ground Height

- MACCS references elevation relative to ground level
  - MELCOR has a relative 0.0 m elevation defined by the analyst (e.g. bottom of the inner surface of RPV set to 0.0 m)
- Define a correction factor to adjust MELCOR flowpath elevations to ground level



# $\sigma_y$ and $\sigma_z$

- Defines the initial plume dimensions in the crosswind ( $\sigma_y$ ) and vertical dimensions ( $\sigma_z$ ) for each plume released
  - Plume dimensions at a downwind distance of zero
    - Estimates dispersion from building wake effects at the initial release
  - Serve as boundary conditions for calculating virtual source location
- $\sigma_y = \frac{W}{4.3}$ 
  - $W$  is the building width at the release point
- $\sigma_z = \frac{H}{2.15}$ 
  - $H$  is the building height at the release point



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# FL\_MACCS

FL\_MACCS MACCSN NFL MACCSname MACCSnum MCCSFP DIRFL DF

- MELCOR outputs the cumulative mass released through a flow path for each particle size bin in kg
  - MACCS-R-M-RE-C.N
    - R – flow path number
    - C – Class number
    - N – particle size bin number
  - Particle size bin 0 reflects vapor phase
- NOTE: Can be used to force MELCOR to write data to the plot file
  - MACCS expects flow to the environment
  - DF parameter on FL\_MACCS card controls if output is MACCS flow path (i.e. to environment)
    - Default is MACCS (i.e. flow to the environment)
  - *If not defined appropriately, MelMACCS can double count the radionuclide release leading to an error in the MACCS input*
- Additional output: SCRAM time, Number of particle bins and size of the particles, Chemical groups and initial mass of chemical groups, Flow path release height, fluid temperature, sensible heat, fluid flow rate, molecular weight

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# Plume Segments

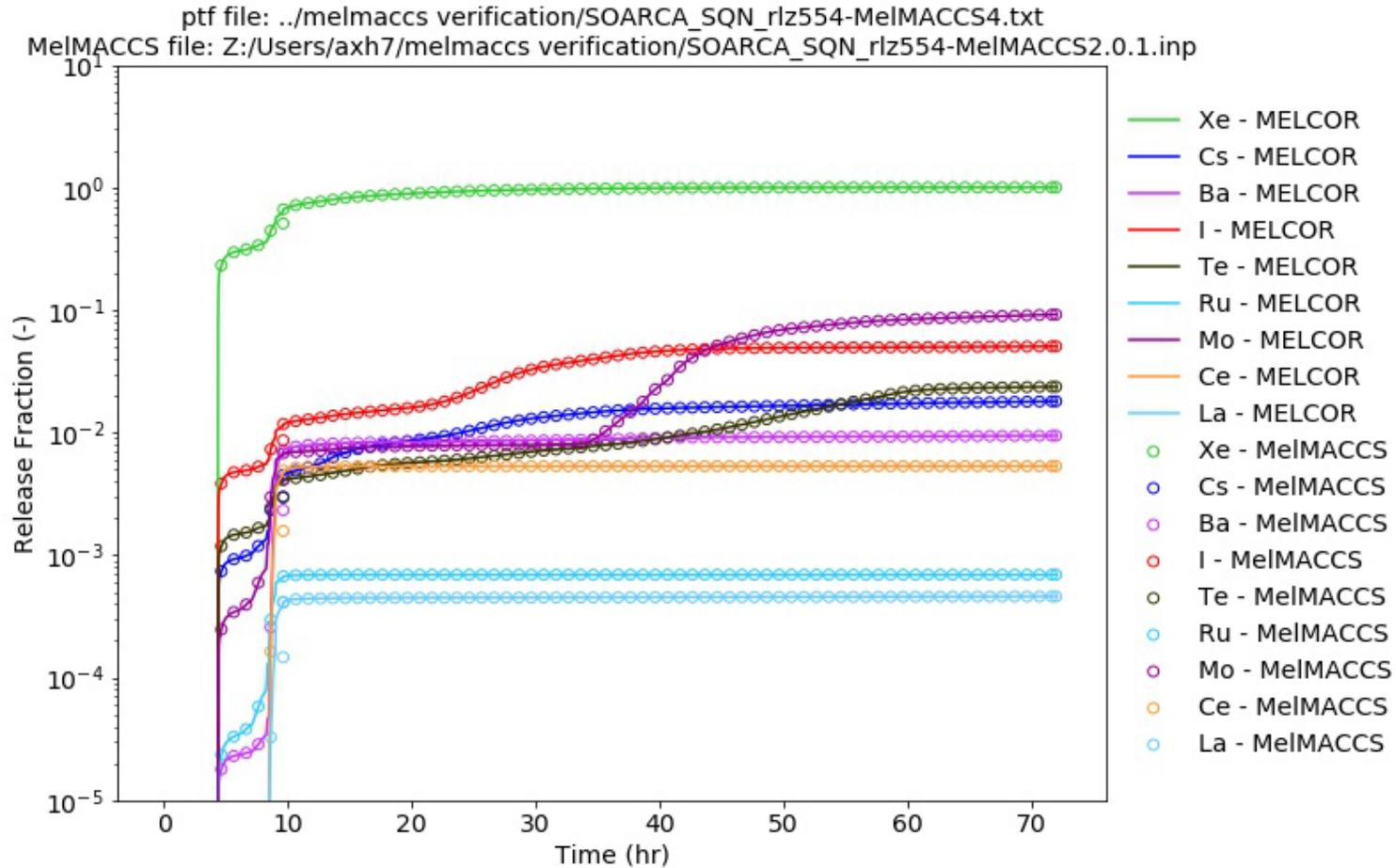
- MACCS performs consequence calculations using plume segments of chemical groups
- Plume Segments have a start time (RDPDELAY) and a duration (RDPLUDUR)
  - A reference time corrects for differences between SCRAM time and accident initiation
  - $PDELAY + t_{Reference}$  and  $PDELAY + PLUDUR + t_{reference}$  is equivalent to MELCOR time
- Plume segments define information related to the source term and the location of the release
  - **Location of release:** Building height (WEBUILDH), Building width (WEBUILDW), Building length (WEBUILDL), Incident wind angle (WEBUILD A), Trapped plume release height (RDPHTRAP), Initial Sigma-Y width (SIGYINIT), Initial Sigma-Z width (SIGZINIT), Height of release (RDPLHITE)
  - **Source Term:** Particle size distribution of chemical classes, Start of plume segment release (RDPDELAY), Plume segment duration (RDPLUDUR), Release of sensible heat (RDPLHEAT), Mass flow rate (RDPLMFLA), Gas density (RDPLMDEN), Release fraction of chemical classes (RDRELFRC)

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# Release Fraction (RDRELFRC)

- RDRELFRC – mass of a chemical class released during a plume segment through a flowpath divided by the initial chemical class mass
- MELCOR Outputs used:  $\frac{\text{MACCS-R-M-RE-C.N}}{\text{MACCS-INITIAL-MASS (C)}}$ 
  - $R$  is the flow path,  $C$  is the chemical class, and  $N$  is the particle size bin (0-10)
  - Particle size bin 0 represents vapor
  - Sum of  $\text{MACCS-R-M-RE-C.N}$  for a flow path and chemical class reflects the total chemical class mass released through a flow path
- Dividing the mass released during the plume segment (i.e. released for PLUDUR at PDELAY) yields the release fraction for that plume segment

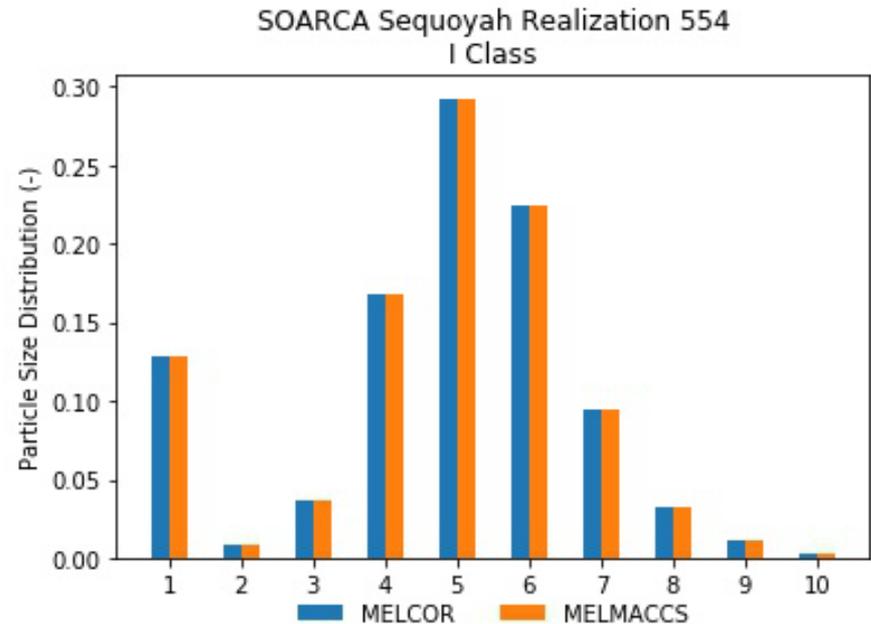
# Release Fraction Comparison



# Particle Size Distribution (RDPSDIST)

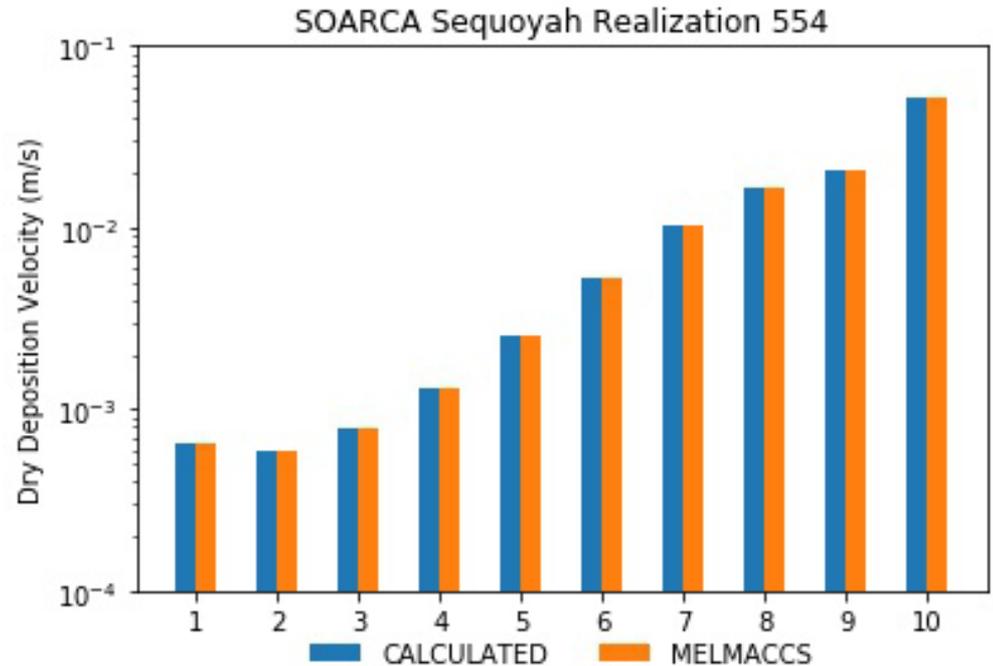
- RDPSDIST – Fraction of a chemical group associated with a particle size bin
- MELCOR Outputs used:
  - MACCS-R-M-RE-C.N
- The total mass released in a particle size bin of a chemical class for all flow paths divided by the total mass released by a class
  - N is for particle bins 1 through 10
  - Neglects vapor

$$RDPSDIST_{C,N} = \frac{\sum_R MACCS-R-M-RE-C.N(t_{final})}{\sum_{R,N} MACCS-R-M-RE-C.N(t_{final})}$$



# Deposition Velocity

- Two options available
  - Gravitational Settling
    - Dependent on aerosol size
    - Independent of wind conditions or surface roughness
  - Expert Elicitation Data
    - Wind speed and surface roughness considered as variables
    - Two wind speeds (2 and 5 m/s) and three surface types with representative surface roughness
    - Choose representative wind speed, surface roughness, and quantile of distribution
    - If aerodynamic particle diameter ( $d_p$ ) is greater than cutoff diameter the calculation is switched to gravitational settling
      - Output value is larger value of the value calculated using gravitational settling versus the value calculated using expert elicitation



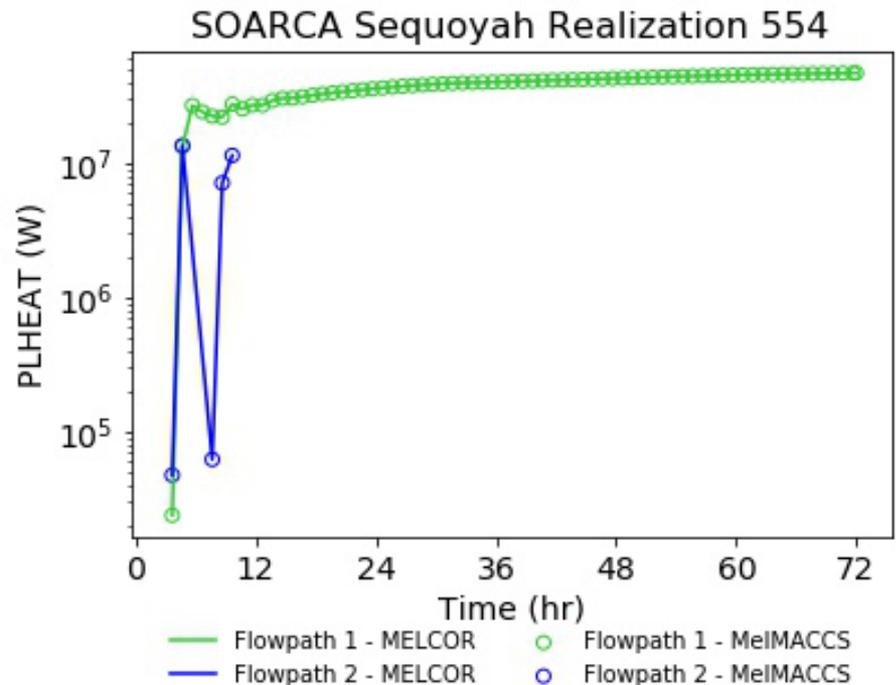
# Sensible Heat (RDPLHEAT)

- RDPLHEAT – Rate of sensible heat released
- Used to determine buoyancy flux using the *Power Model*
  - Plume rise occurs only when wind speed at release of plume segment is less than critical wind speed calculated using sensible heat

- MELCOR Outputs Used:

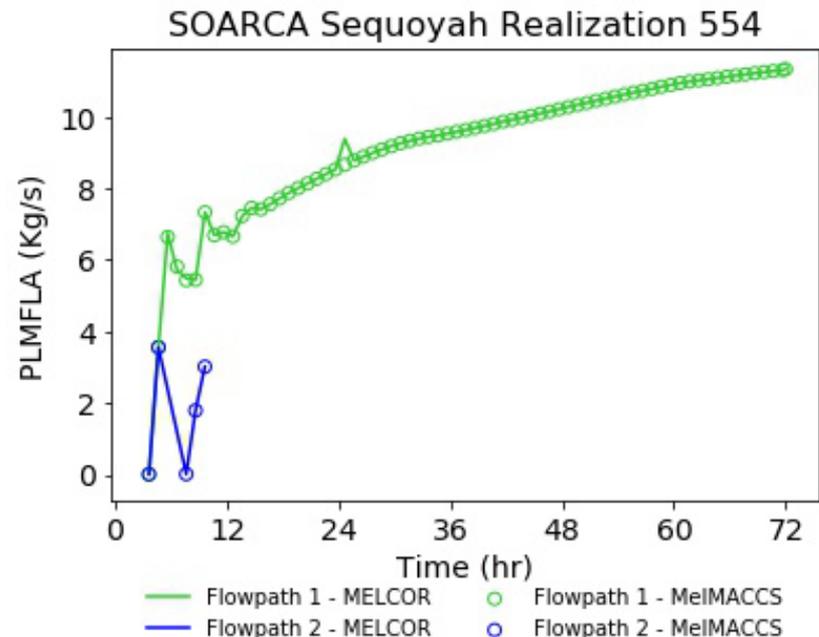
MACCS-R-PLHEAT.0

- $RDPLHEAT = \frac{(H(R,T_2) - H(R,T_1))}{(T_2 - T_1)}$ 
  - $H(R,T_2) = MACCS - R - PLHEAT.0(t_2)$
  - $T_2 = PDELAY + PLUDUR + t_{reference}$
  - $H(R,T_1) = MACCS - R - PLHEAT.0(t_1)$
  - $T_1 = PDELAY + t_{reference}$



# Average Plume Flow Rate (RDPLMFLA)

- RDPLMFLA – Average flow rate for plume segment in units of kg/s
  - Used to calculate buoyancy flux using Density and Flow model
- MELCOR Outputs used:
  - MACCS-R-PLMFLO.0
  - MACCS-R-PLMWT.0
  - Converts MELCOR fluid mass flow rate in moles to kg by multiplying by average molecular weight
- $Flow_i = \frac{(PLMFLO_i - PLMFLO_{i-1}) * (PLMWT_i + PLMWT_{i-1})}{2}$ 
  - $PLMFLO_i = MACCS - R - PLMFLO.0(i)$
  - $PLMFLO_{i-1} = MACCS - R - PLMFLO.0(i - 1)$
  - $PLMWT_i = MACCS - R - PLMWT.0(i)$
  - $PLMWT_{i-1} = MACCS - R - PLMWT.0(i - 1)$
- $RDPLMFLA = \frac{1}{T_2 - T_1} \sum_{i=1}^m Flow_i$ 
  - $T_2 = PDELAY + PLUDUR + t_{reference}$
  - $T_1 = PDELAY + t_{reference}$



# Plume Gas Density (RDPLMDEN)

- RDPLMDEN – Average gas density over all time steps in a plume segment
  - Used to calculate buoyancy flux using Density and Flow model

- MELCOR Outputs used: MACCS-R-PLMFLO.0  
MACCS-R-PLMWT.0  
MACCS-R-PLTEMP.0

$$F_i = \frac{MACCS-R-PLMWT.0(t_i)}{MACCS-R-PLTEMP.0(t_i)}$$

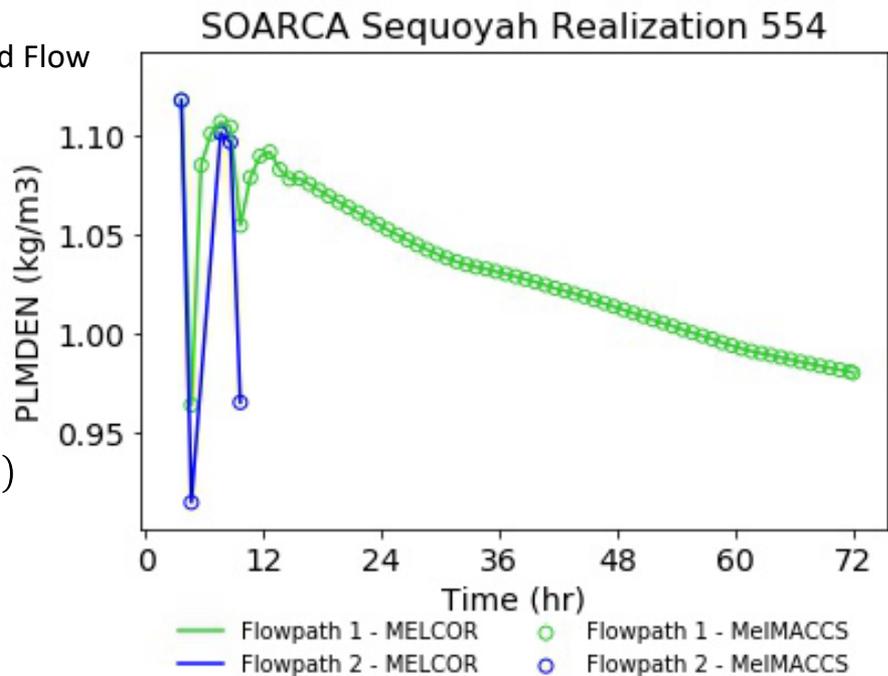
$$F_{average} = \frac{1}{PLMFLO(T_2) - PLMFLO(T_1)} * \frac{1}{2} \sum (F_i + F_{i-1})(PLMFLO(t_i) - PLMFLO(t_{i-1}))$$

$$PLMDEN = F_{average} \left( \frac{p_o}{r_u} \right)$$

- $p_o = 1.012 \text{ bar}$

- $r_u = 8.314 \times 10^{-5} \frac{\text{bar} \cdot \text{m}^3}{\text{mol} \cdot \text{K}}$

- Ideal Gas Equation:  $pV = nrT \Rightarrow \frac{m}{V} = \left( \frac{p}{r} \right) \left( \frac{M}{T} \right)$



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# Activity Calculation

- MACCS code converts plume segment release fractions of chemical classes to released isotopic activity
- MelMACCS inventory defines radionuclide mass (kg) and activity (Ci)
- Radionuclides are mapped to chemical classes
  - Sum of the radionuclide masses in a chemical class is equal to ELMMAS of the MELCOR DCH\_EL card

$$CoreInventory_{nuclide} = \frac{MACCS-INITIAL-MASS(C)}{MassInventory,C} Activity_{nuclide}$$

# Activity Calculation

- MACCS prints the radionuclide activity per plume segment as a data block in the output file
  - Data block heading:  
*RELEASED INVENTORY (Ci) OF ALL PLUMES*

| Radionuclide | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | 10       | 11      |
|--------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|---------|
| Kr-85        | 1.80E-02 | 3.60E-02 | 1.34E+05 | 1.09E+05 | 7.18E+04 | 1.63E+04 | 2.80E+04 | 7.67E+01 | 7.34E+04 | 3.92E+04 | 1.59E+0 |
| Kr-85m       | 3.29E-01 | 6.07E-01 | 1.94E+06 | 1.57E+06 | 8.90E+05 | 1.73E+05 | 2.54E+05 | 6.97E+02 | 5.72E+05 | 3.05E+05 | 1.06E+0 |
| Kr-87        | 2.32E-01 | 3.52E-01 | 7.59E+05 | 6.16E+05 | 2.36E+05 | 3.11E+04 | 3.09E+04 | 8.47E+01 | 4.70E+04 | 2.51E+04 | 5.91E+0 |
| Kr-88        | 6.89E-01 | 1.22E+00 | 3.54E+06 | 2.88E+06 | 1.49E+06 | 2.65E+05 | 3.56E+05 | 9.76E+02 | 7.32E+05 | 3.91E+05 | 1.24E+0 |
| Xe-133       | 3.67E+00 | 7.31E+00 | 2.70E+07 | 2.20E+07 | 1.44E+07 | 3.26E+06 | 5.56E+06 | 1.52E+04 | 1.45E+07 | 7.75E+06 | 3.13E+0 |
| Xe-135       | 9.37E-01 | 1.80E+00 | 6.18E+06 | 5.02E+06 | 3.08E+06 | 6.48E+05 | 1.03E+06 | 2.83E+03 | 2.54E+06 | 1.36E+06 | 5.13E+0 |
| Xe-135m      | 1.24E-02 | 2.26E-02 | 4.06E+04 | 3.38E+04 | 1.67E+04 | 2.80E+03 | 5.11E+03 | 1.36E+01 | 1.67E+04 | 9.55E+03 | 3.51E+0 |
| Cs-134       | 1.96E-03 | 3.91E-03 | 6.20E+03 | 4.93E+03 | 2.99E+03 | 9.23E+02 | 3.05E+03 | 7.92E+00 | 1.11E+04 | 6.31E+03 | 2.26E+0 |
| Cs-136       | 7.09E-04 | 1.41E-03 | 2.23E+03 | 1.78E+03 | 1.07E+03 | 3.31E+02 | 1.09E+03 | 2.83E+00 | 3.97E+03 | 2.25E+03 | 8.05E+0 |
| Cs-137       | 1.39E-03 | 2.77E-03 | 4.38E+03 | 3.49E+03 | 2.11E+03 | 6.53E+02 | 2.16E+03 | 5.60E+00 | 7.86E+03 | 4.46E+03 | 1.60E+0 |
| Rb-86        | 2.43E-05 | 4.84E-05 | 7.66E+01 | 6.09E+01 | 3.68E+01 | 1.14E+01 | 3.75E+01 | 9.73E-02 | 1.36E+02 | 7.74E+01 | 2.77E+0 |
| Rb-88        | 7.66E-01 | 1.36E+00 | 3.96E+06 | 3.21E+06 | 1.66E+06 | 2.96E+05 | 3.98E+05 | 1.09E+03 | 8.17E+05 | 4.37E+05 | 1.39E+0 |
| Ba-139       | 6.69E-05 | 1.04E-04 | 2.56E+02 | 1.88E+02 | 8.02E+01 | 1.21E+01 | 2.43E+01 | 4.53E-02 | 5.46E+02 | 2.28E+02 | 9.79E+0 |
| Ba-140       | 2.44E-04 | 4.86E-04 | 1.98E+03 | 1.45E+03 | 1.02E+03 | 2.54E+02 | 8.45E+02 | 1.58E+00 | 3.13E+04 | 1.30E+04 | 9.25E+0 |
| Sr-89        | 1.36E-04 | 2.72E-04 | 1.11E+03 | 8.14E+02 | 5.74E+02 | 1.43E+02 | 4.75E+02 | 8.86E-01 | 1.76E+04 | 7.35E+03 | 5.22E+0 |
| Sr-90        | 1.04E-05 | 2.07E-05 | 8.48E+01 | 6.22E+01 | 4.38E+01 | 1.09E+01 | 3.63E+01 | 6.78E-02 | 1.35E+03 | 5.62E+02 | 4.00E+0 |
| Sr-91        | 1.41E-04 | 2.72E-04 | 1.03E+03 | 7.58E+02 | 4.96E+02 | 1.15E+02 | 3.56E+02 | 6.63E-01 | 1.23E+04 | 5.12E+03 | 3.38E+0 |
| Sr-92        | 9.31E-05 | 1.63E-04 | 5.17E+02 | 3.79E+02 | 2.07E+02 | 3.99E+01 | 1.03E+02 | 1.92E-01 | 2.96E+03 | 1.23E+03 | 6.78E+0 |
| Ba-137m      | 1.31E-03 | 2.62E-03 | 4.15E+03 | 3.30E+03 | 2.00E+03 | 6.18E+02 | 2.04E+03 | 5.30E+00 | 7.44E+03 | 4.22E+03 | 1.51E+0 |
| I-131        | 4.90E-02 | 9.75E-02 | 1.96E+05 | 1.63E+05 | 8.92E+04 | 1.68E+04 | 3.35E+04 | 8.94E+01 | 1.21E+05 | 6.93E+04 | 2.82E+0 |
| I-132        | 4.33E-02 | 7.97E-02 | 1.54E+05 | 1.27E+05 | 6.36E+04 | 1.17E+04 | 2.49E+04 | 6.95E+01 | 8.05E+04 | 4.92E+04 | 1.86E+0 |
| I-133        | 9.36E-02 | 1.84E-01 | 3.57E+05 | 2.98E+05 | 1.58E+05 | 2.85E+04 | 5.59E+04 | 1.49E+02 | 1.96E+05 | 1.12E+05 | 4.43E+0 |
| I-134        | 1.41E-02 | 1.90E-02 | 1.73E+04 | 1.45E+04 | 3.60E+03 | 3.04E+02 | 2.80E+02 | 7.46E-01 | 4.61E+02 | 2.63E+02 | 4.87E+0 |
| I-135        | 7.37E-02 | 1.40E-01 | 2.53E+05 | 2.11E+05 | 1.04E+05 | 1.75E+04 | 3.19E+04 | 8.51E+01 | 1.04E+05 | 5.96E+04 | 2.19E+0 |
| Te-127       | 1.02E-03 | 1.97E-03 | 4.79E+03 | 3.91E+03 | 2.06E+03 | 4.03E+02 | 8.91E+02 | 2.53E+00 | 2.80E+03 | 1.74E+03 | 6.38E+0 |
| Te-127m      | 1.94E-04 | 3.87E-04 | 9.98E+02 | 8.16E+02 | 4.55E+02 | 9.45E+01 | 2.21E+02 | 6.26E-01 | 7.32E+02 | 4.55E+02 | 1.76E+0 |
| Te-129       | 1.09E-03 | 1.84E-03 | 3.63E+03 | 2.97E+03 | 1.38E+03 | 2.55E+02 | 5.54E+02 | 1.57E+00 | 1.76E+03 | 1.09E+03 | 4.14E+0 |
| Te-129m      | 6.83E-04 | 1.36E-03 | 3.51E+03 | 2.87E+03 | 1.60E+03 | 3.32E+02 | 7.74E+02 | 2.20E+00 | 2.57E+03 | 1.59E+03 | 6.18E+0 |

- The end of the plume segment is equal to  $PDELAY + PLUDUR + t_{reference}$ 
  - Sum plume segments with same ending time to determine the activity released at that time from that flowpath

# Activity Calculation

