

# Stability Class Determination Method Impacts on MACCS Outputs

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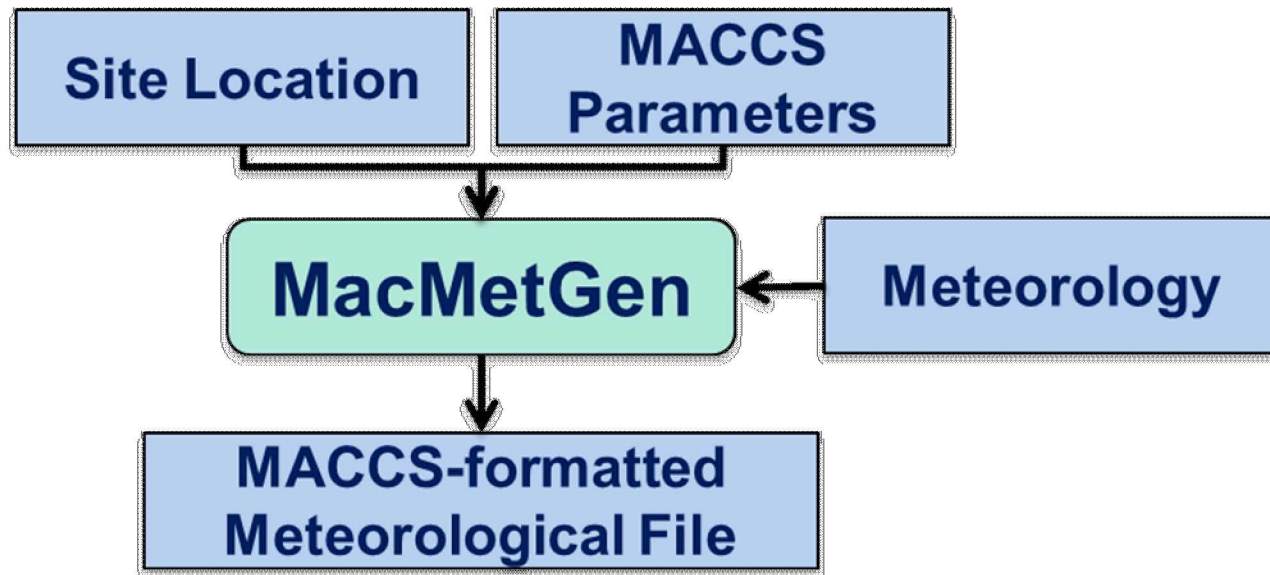
# Outline

- MacMetGen description
- Sensitivity study setup
- Effects of stability class methods on MACCS results

# MacMetGen

- Formatted meteorological file needed for MACCS calculations
- Time consuming to collect site data and compile into file
- MacMetGen developed to automate MACCS formatted meteorological file generation
- Makes use of meteorological files available from the NOAA ARL ftp site
  - Multiple years
  - North American and global data sets
  - Can be any data set if in similar format

# MacMetGen



- Input parameters specified in input file
  - Location
  - Time frame
  - Meteorological data set
  - Stability class determination method
  - MACCS file setup

# Supported Stability Class Determination Methods

- Delta Temperature/Delta Z (height) (DTDZ)
  - Based on the surface vertical temperature gradient
  - Consistent with criteria provided in Reg Guide 1.23 (NRC 2007)
- Turner's method
  - Based on net radiation index, wind speed and cloud cover
  - Consistent with criteria provided in EPA 2000
- Solar Radiation/Delta Temperature (SRDT)
  - Based on solar radiation, wind speed and surface vertical temperature gradient
  - Retains the basic structure of Turner's method, without the need for cloud cover information
  - Consistent with criteria provided in EPA 2000

# Delta Temperature/Delta Height

- Determine temperature gradient from surface to at least 100 m above ground
  - Depends on vertical spacing of meteorological data
- Consistent with criteria below (Reg Guide 1.23, NRC 2007)

<b>Vertical Temperature Gradient Delta T/Delta Z [K/100 m]</b>	<b>Stability Class</b>
< -1.9	1 (A)
-1.9 to -1.7	2 (B)
-1.7 to -1.5	3 (C)
-1.5 to -0.5	4 (D)
-0.5 to 1.5	5 (E)
1.5 to 4.0	6 (F)
> 4.0	7 (G)

# Turner's Method

- Determine net radiation index from procedure defined in EPA 2000.

## Procedure for Determining the Net Radiation Index

1. If the total cloud<sup>1</sup> cover is 10/10 and the ceiling is less than 7000 feet, use net radiation index equal to 0 (whether day or night).
2. For nighttime: (from one hour before sunset to one hour after sunrise):
  - (a) If total cloud cover  $\leq 4/10$ , use net radiation index equal to -2.
  - (b) If total cloud cover  $> 4/10$ , use net radiation index equal to -1.
3. For daytime:
  - (a) Determine the insolation class number as a function of solar altitude from Table 6-5.
  - (b) If total cloud cover  $\leq 5/10$ , use the net radiation index in Table 6-4 corresponding to the insolation class number.
  - © If cloud cover  $> 5/10$ , modify the insolation class number using the following six steps.
    - (1) Ceiling  $< 7000$  ft, subtract 2.
    - (2) Ceiling  $\geq 7000$  ft but  $< 16000$  ft, subtract 1.
    - (3) total cloud cover equal 10/10, subtract 1. (This will only apply to ceilings  $\geq 7000$  ft since cases with 10/10 coverage below 7000 ft are considered in item 1 above.)
    - (4) If insolation class number has not been modified by steps (1), (2), or (3) above, assume modified class number equal to insolation class number.
    - (5) If modified insolation class number is less than 1, let it equal 1.
    - (6) Use the net radiation index in Table 6-4 corresponding to the modified insolation class number.

Table 6-5

Insolation Class as a Function of Solar Altitude

Solar Altitude $\Phi$ (degrees)	Insolation	Insolation Class Number
$60 < \Phi$	strong	4
$35 < \Phi \leq 60$	moderate	3
$15 < \Phi \leq 35$	slight	2
$\Phi \leq 15$	weak	1

EPA 2000

# Turner's Method

- Based on combination of wind speed and net radiation index to determine stability class

Table 6-4  
Turner's Key to the P-G Stability Categories

Wind Speed		Net Radiation Index						
(knots)	(m/s)	4	3	2	1	0	-1	-2
0,1	0 - 0.7	1	1	2	3	4	6	7
2,3	0.8 - 1.8	1	2	2	3	4	6	7
4,5	1.9 - 2.8	1	2	3	4	4	5	6
6	2.9 - 3.3	2	2	3	4	4	5	6
7	3.4 - 3.8	2	2	3	4	4	4	5
8,9	3.9 - 4.8	2	3	3	4	4	4	5
10	4.9 - 5.4	3	3	4	4	4	4	5
11	5.5 - 5.9	3	3	4	4	4	4	4
≥ 12	≥ 6.0	3	4	4	4	4	4	4

EPA 2000

# Solar Radiation/Delta Temperature

- Day - determine solar radiation
- Night - determine vertical temperature gradient
- Find stability class as a function of wind speed

Table 6-7  
Key to Solar Radiation Delta-T (SRDT) Method for Estimating  
Pasquill-Gifford (P-G) Stability Categories

DAYTIME				
Wind Speed (m/s)	Solar Radiation (W/m <sup>2</sup> )			
	≥ 925	925 - 675	675 - 175	< 175
< 2	A	A	B	D
2 - 3	A	B	C	D
3 - 5	B	B	C	D
5 - 6	C	C	D	D
≥ 6	C	D	D	D

NIGHTTIME		
Wind Speed (m/s)	Vertical Temperature Gradient	
	< 0	≥ 0
< 2.0	E	F
2.0 - 2.5	D	E
≥ 2.5	D	D

EPA 2000

# Sensitivity Study Setup

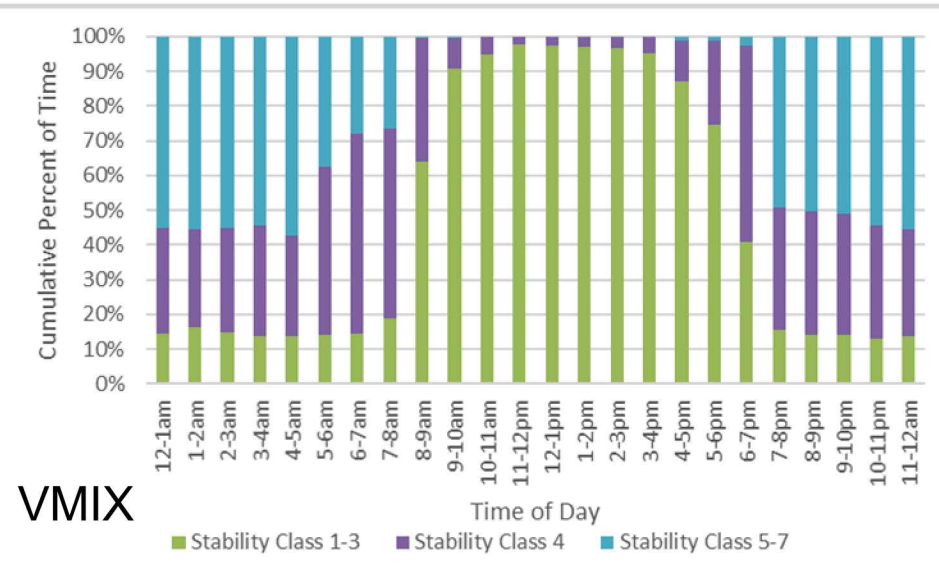
- Large river valley site
- Source term
  - NUREG-1150 historic (puff release followed by a longer duration tail)
- General evacuation scheme
  - Modeled with multiple evacuating cohorts
- MACCS Gaussian Plume Segment atmospheric transport and dispersion model
- Weather bin sampling
  - ~900 samples
  - Mean, 95<sup>th</sup> and 5<sup>th</sup> percentiles
- NAM12 meteorological data set
- Three stability class determination methods
  - DTDZ – MacMetGen
  - SRDT – MacMetGen
  - VMIX – HYSPLIT
    - Stability class determined from wind speed and turbulent kinetic energy

# Output Metrics

- Peak (around the compass) time-integrated air concentration ( $\chi/Q$ ,  $s/m^3$ )
- Peak (around the compass) ground deposition ( $D/Q$ ,  $1/m^2$ )
- Normalized peak dose (unitless)
- Normalized population-weighted early fatality risk within a circular area near the point of release
- Normalized regional population doses
- Normalized population-weighted latent cancer fatality risk over region
- Normalized land areas that exceed various levels of contamination
- Normalized total regional economic losses

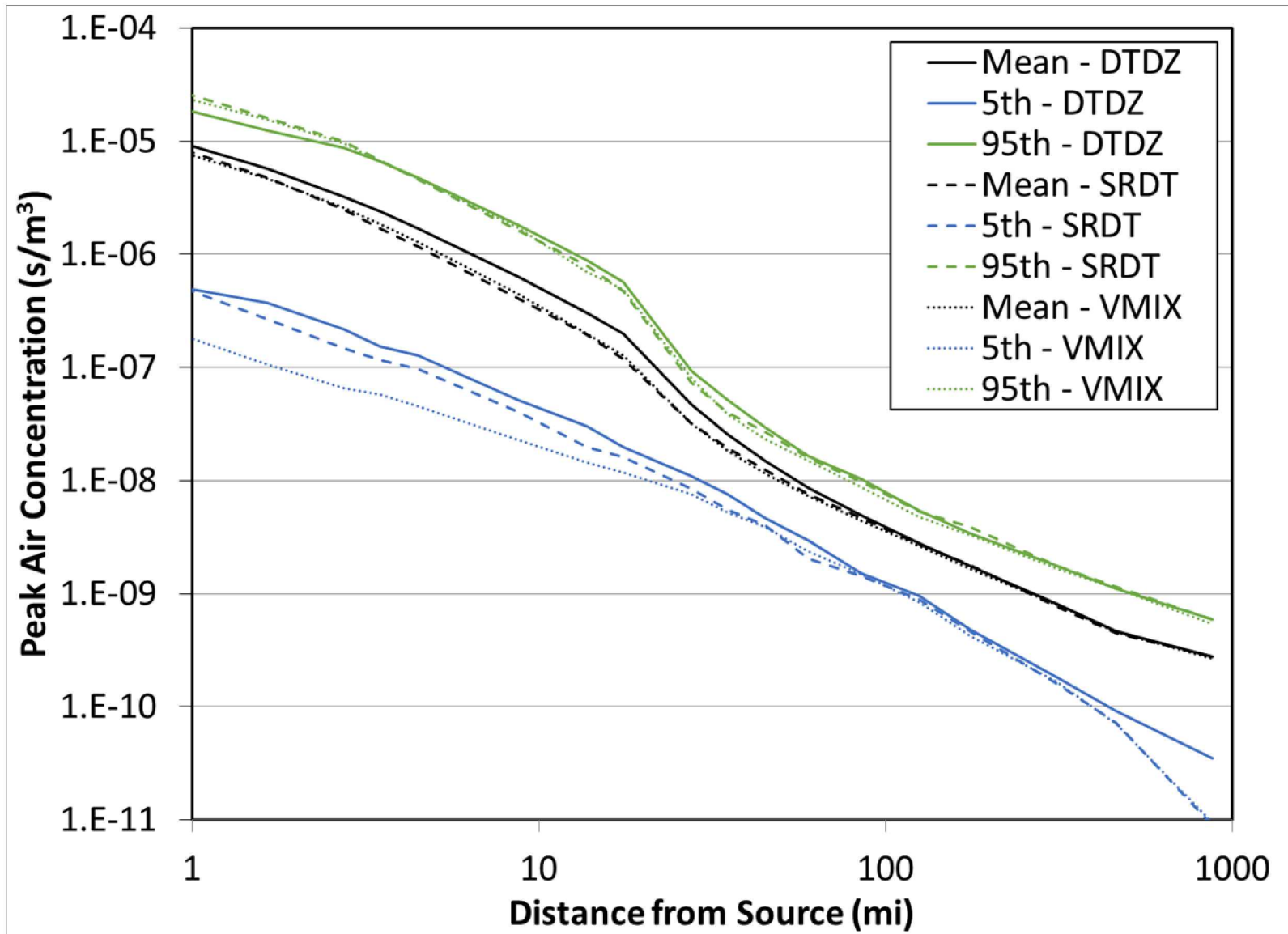
# Stability Class Differences

- DTDZ – Highest probability of stable conditions
- SRDT – Highest probability of neutral conditions
- VMIX – Highest probability of unstable conditions



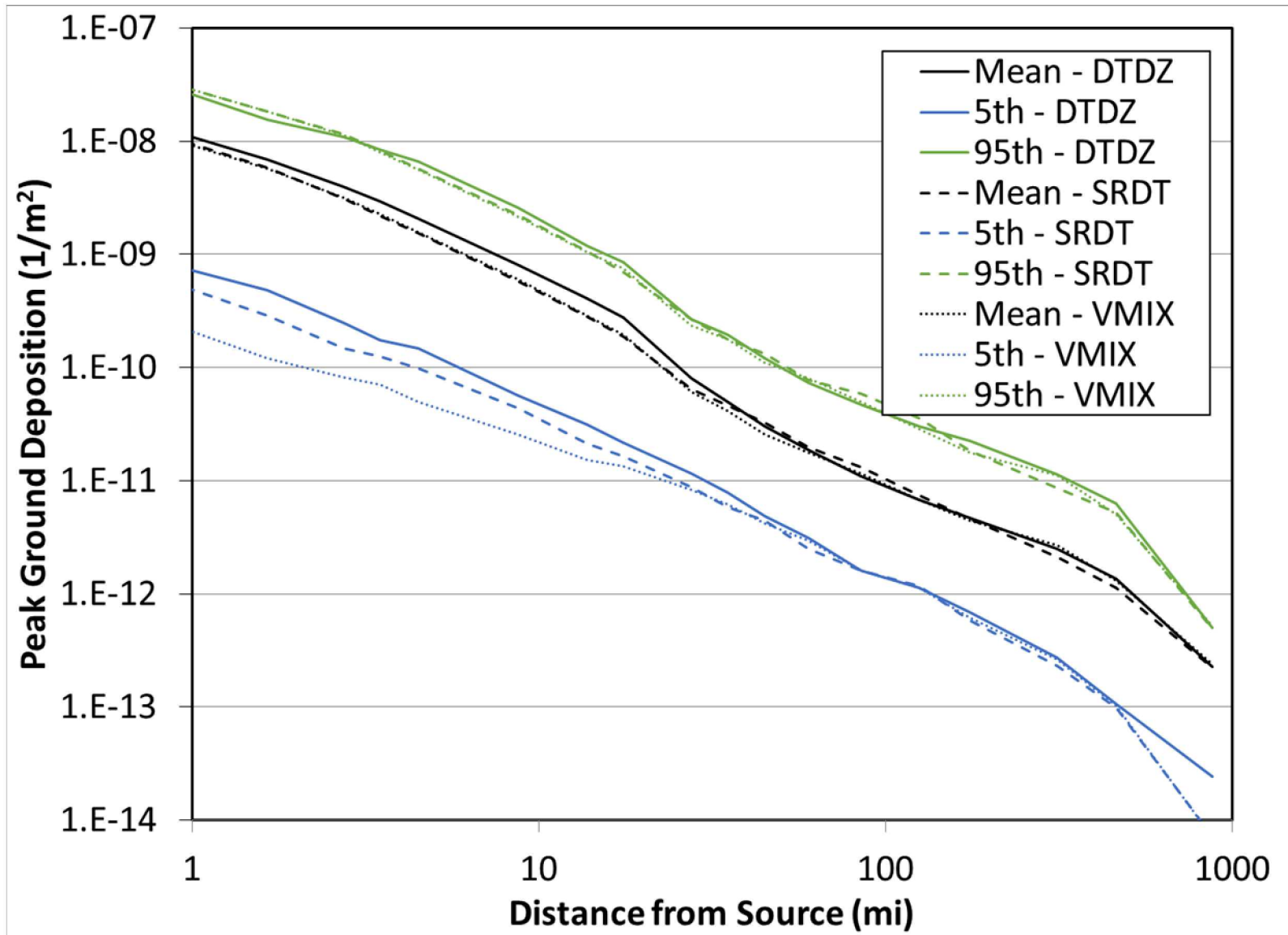
# Comparison #1 Peak Air Concentration

(Large River Valley, NUREG-1150 Source Term)



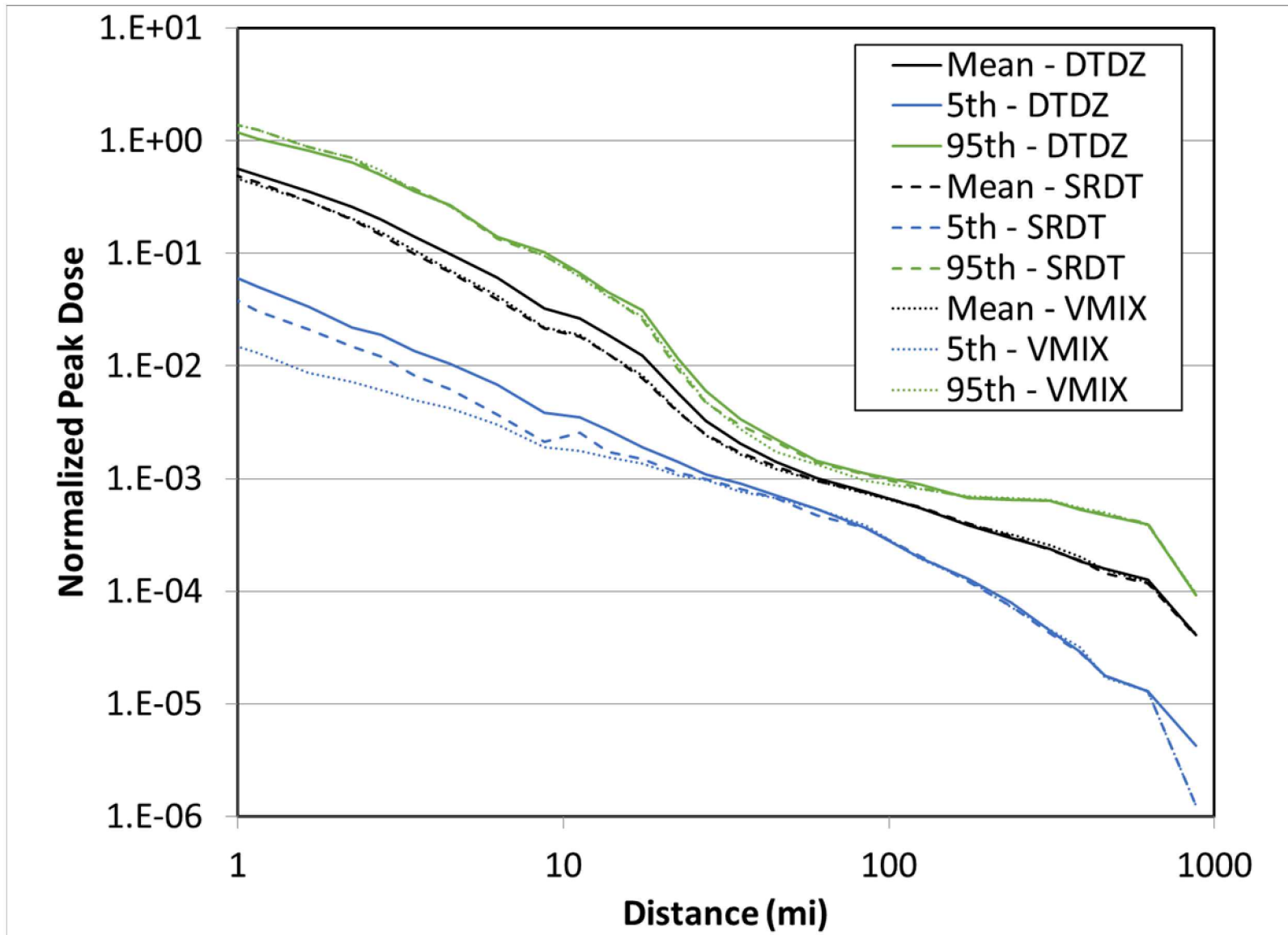
# Comparison #1 Peak Ground Deposition

(Large River Valley, NUREG-1150 Source Term)



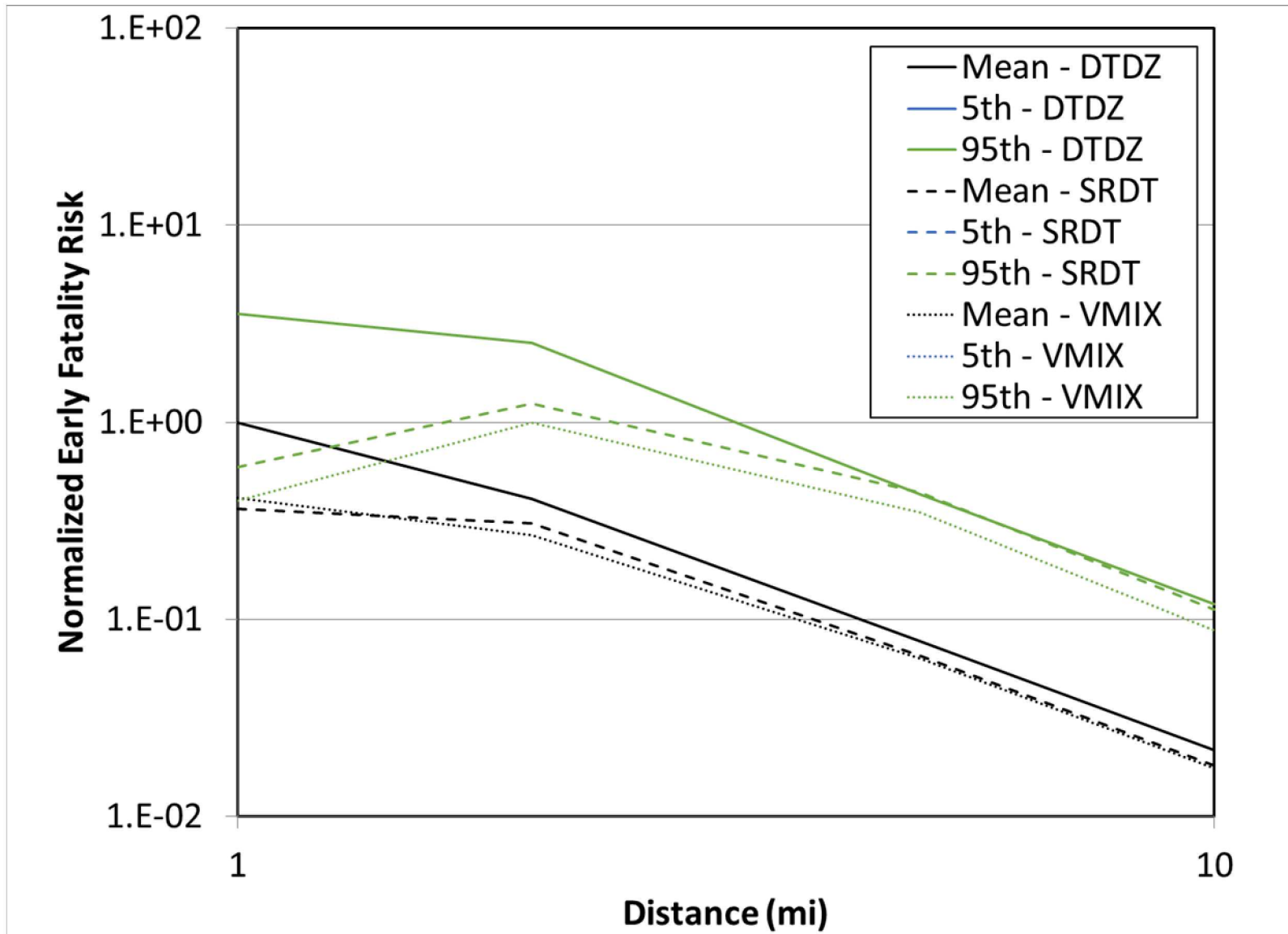
# Comparison #1 Peak Dose

(Large River Valley, NUREG-1150 Source Term)



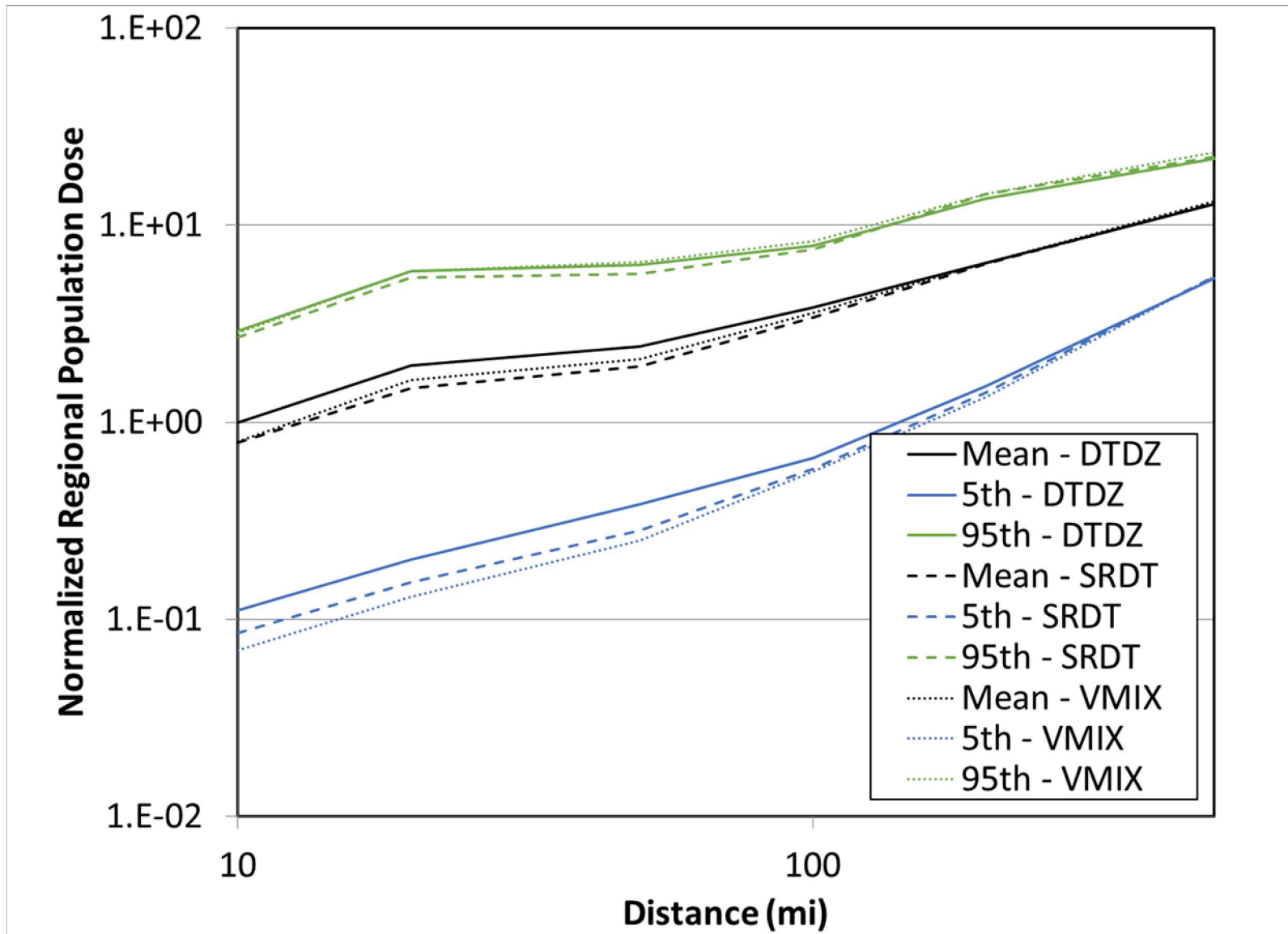
# Comparison #1 Early Fatality Risk

(Large River Valley, NUREG-1150 Source Term)



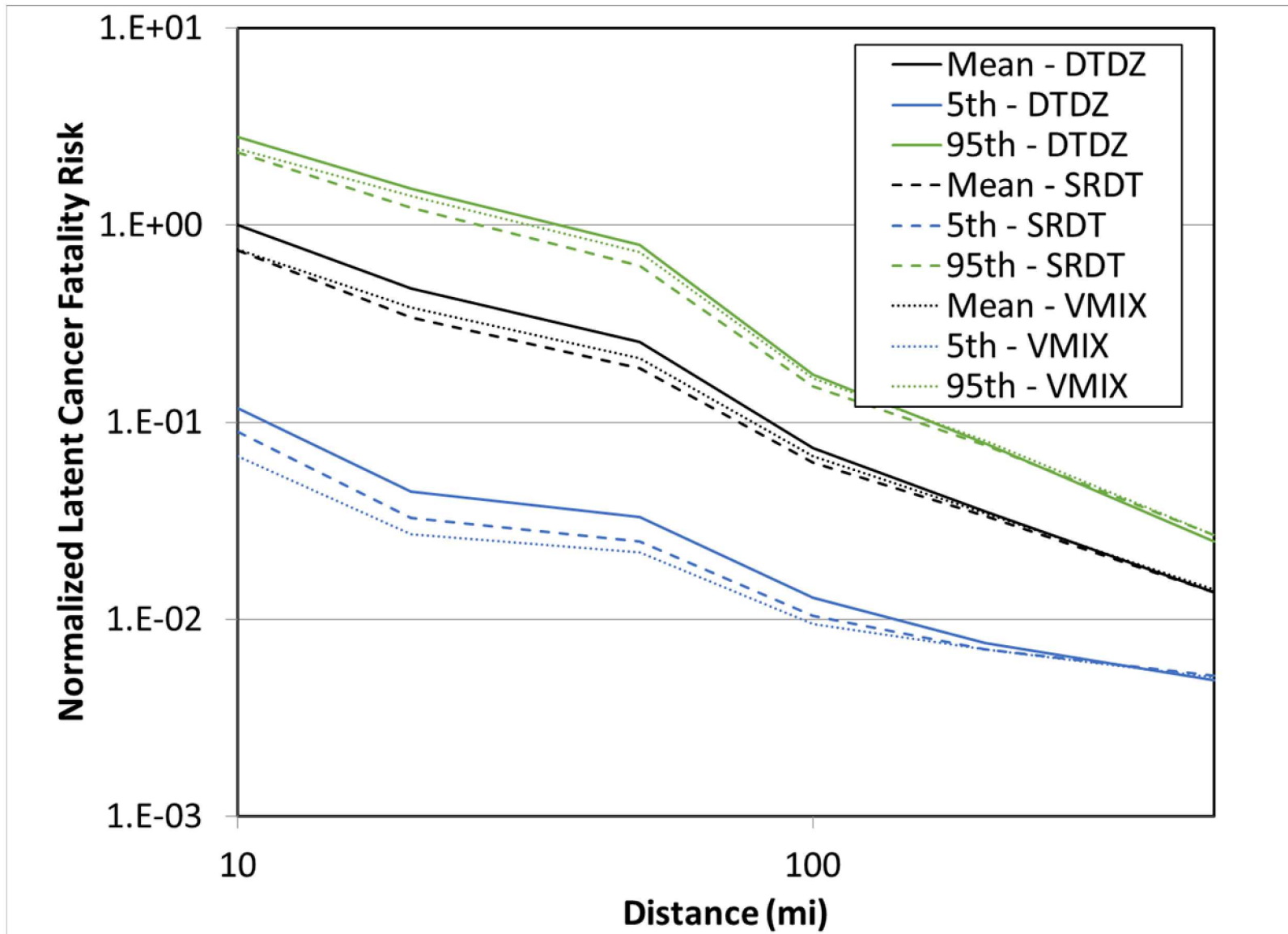
# Comparison #1 Population Dose

(Large River Valley, NUREG-1150 Source Term)



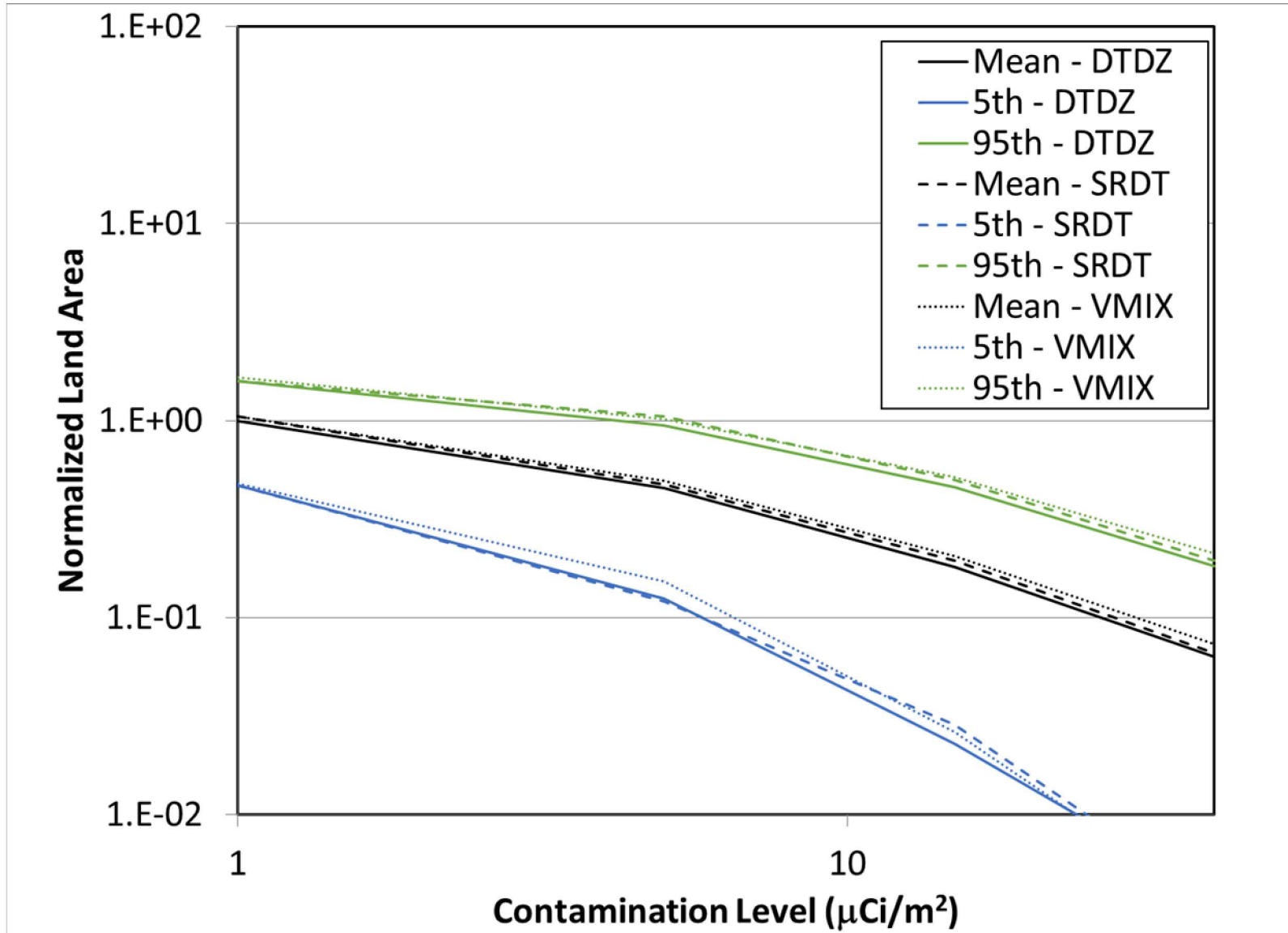
# Comparison #1 Latent Cancer Fatality Risk

(Large River Valley, NUREG-1150 Source Term)



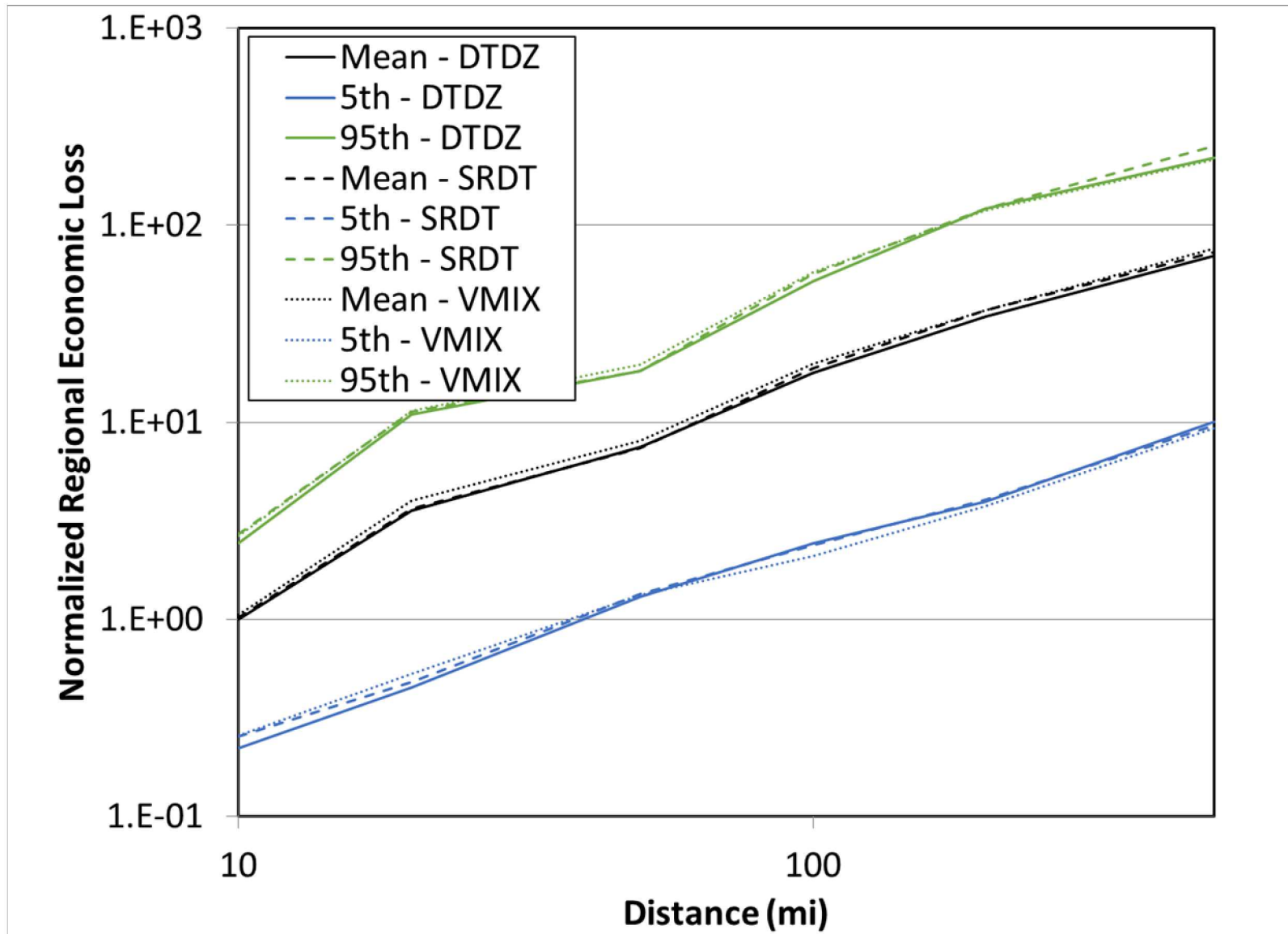
# Comparison #1 Land Contamination Area

(Large River Valley, NUREG-1150 Source Term)



# Comparison #1 Economic Loss

(Large River Valley, NUREG-1150 Source Term)



# Summary

- High level of agreement between all three cases
- The largest differences are at short distances (<30 mi)
- Very similar at longer distances due to change to time-based dispersion which is not a function of stability class
  
- DTDZ (more stable conditions)
  - Highest peak air concentration, peak ground deposition, peak dose, normalized regional population does and latent cancer fatality risk
- VMIX (more unstable conditions)
  - Lowest in same categories
- SRDT (more neutral condition)
  - In between

# References

- EPA (2000). “Meteorological Monitoring Guidance for Regulatory Modeling Application.” EPA-454/R-99-005. February 2000.
- NRC (2007). “Meteorological Monitoring Programs for Nuclear Power Plants, Revision 1.” Regulatory Guide 1.23. March 2007.

# Backup

# Stability Class Differences

- DTDZ – Highest probability of stable conditions
- SRDT – Highest probability of neutral conditions
- VMIX – Highest probability of unstable conditions

