

Results of Benchmark Exercise with MACCS-HYSPLIT Atmospheric Transport and Dispersion Model Implementation

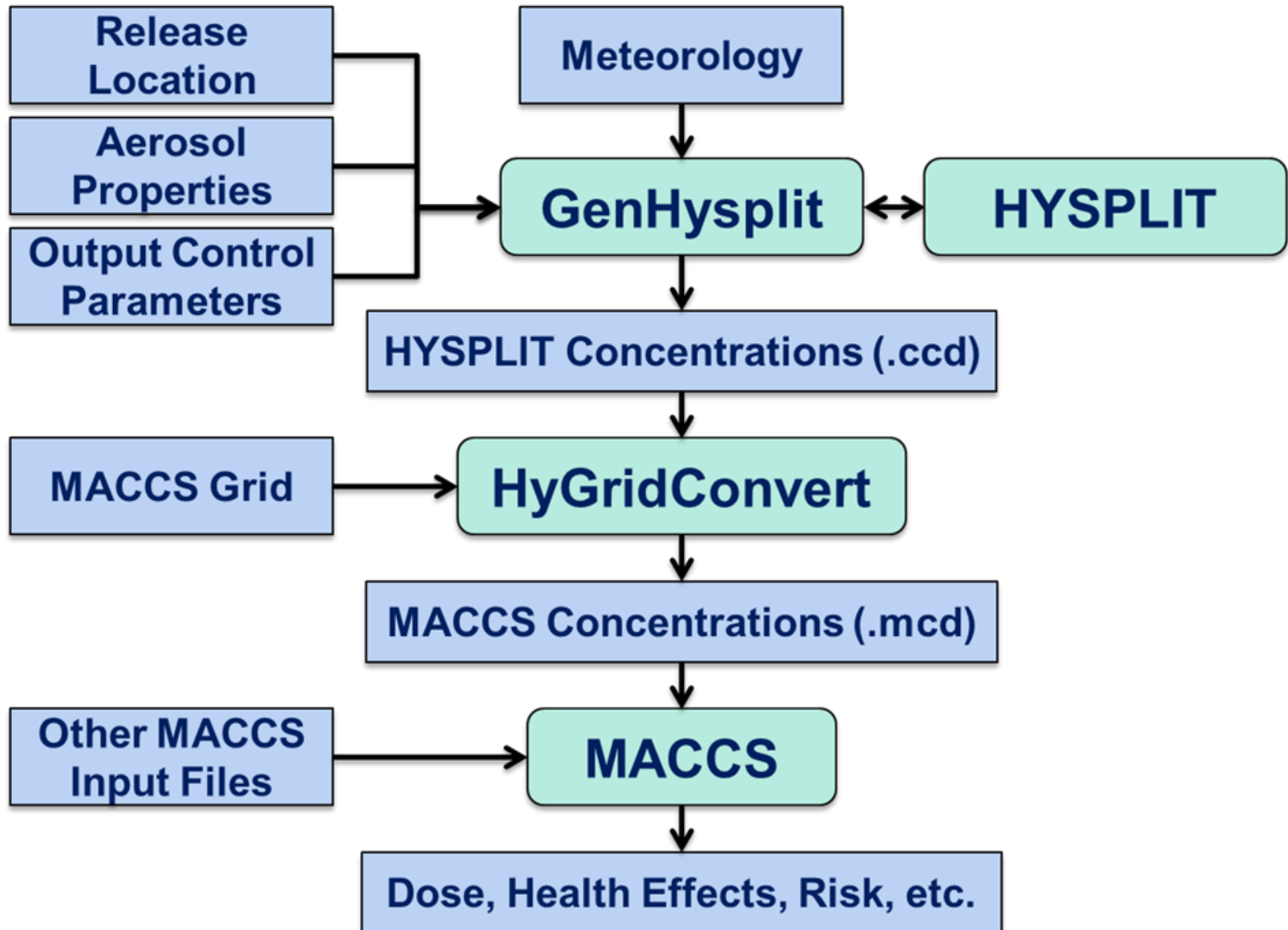
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Sandia National Laboratories
U.S. Nuclear Regulatory Commission

June 2018

International MACCS Users' Group Meeting

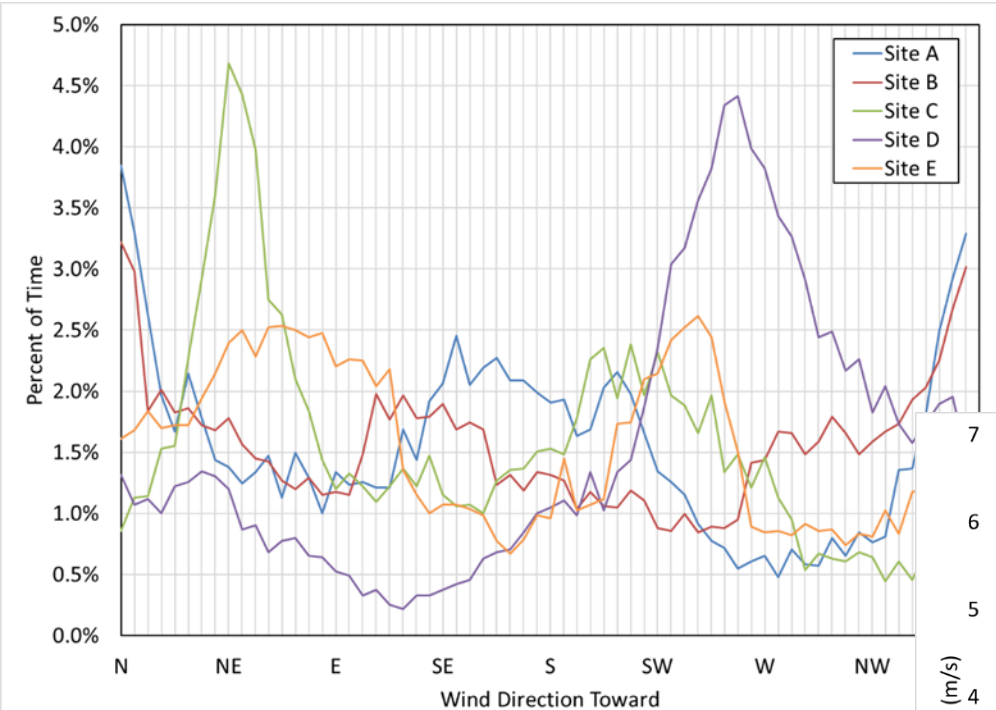
- Integration of HYSPLIT atmospheric transport results into MACCS
- Benchmarking results
- Summary

MACCS-HYSPLIT Coupling Process

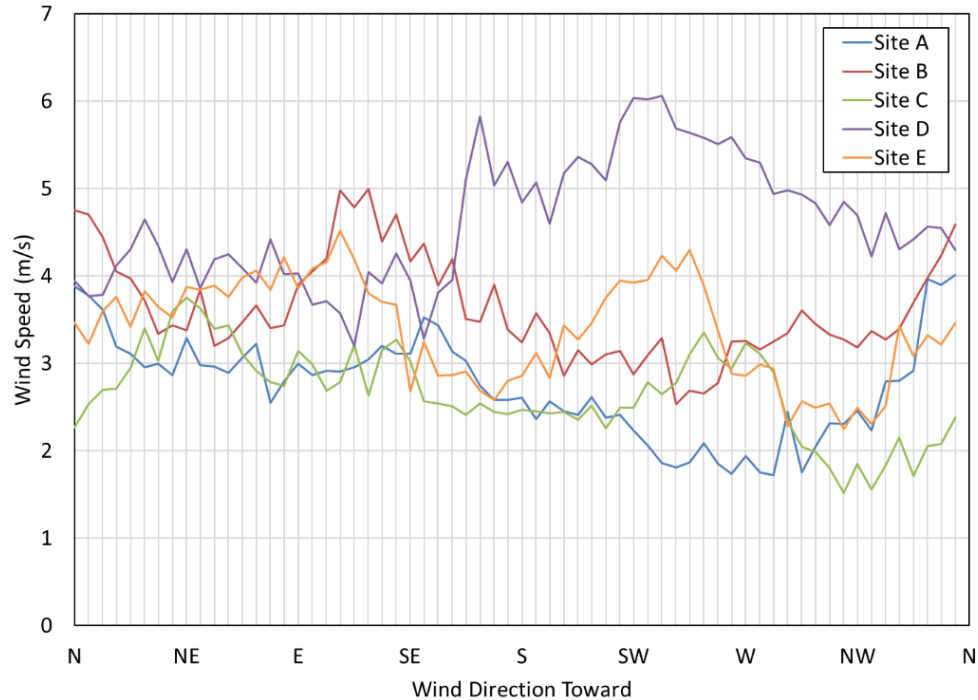


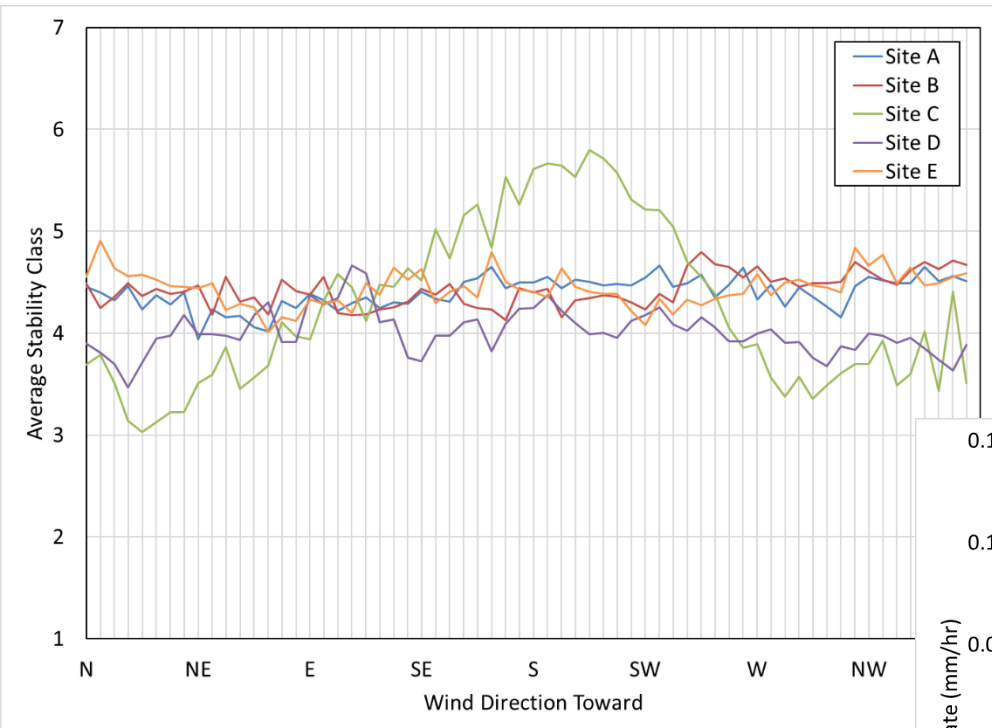
- ATMOS
 - Source term definition
 - Weather sampling algorithms
 - Atmospheric transport, dispersion, and deposition
 - Compare HYSPLIT and Gaussian model
- EARLY (1 to 40 days)
 - Doses as modified by emergency-phase countermeasures such as sheltering, evacuation, relocation, and KI ingestion
 - Multiple population cohorts may be modeled
 - Acute and latent health effects from early acute exposure
- CHRONC (1 week to >50 years)
 - Doses as modified by intermediate and recovery-phase protective actions such as relocation, interdiction, decontamination, and condemnation
 - Latent health effects from chronic exposure to deposited material
 - Economic impact from early and late phase protective actions

- Five representative sites
 - Site A - Large river valley
 - Site B - Central midwestern plain
 - Site C - Dry western region
 - Site D - Atlantic coast with potential for sea breezes
 - Site E - Southeast river valley influenced by Bermuda high
- Source term
 - #1 - NUREG-1150 historic (puff release followed by a longer duration tail)
 - #2 - SOARCA Short-Term Station Blackout (more delayed and prolonged)
- General evacuation scheme
 - Modeled with multiple evacuating cohorts
- Weather Sampling
 - Weather bin sampling (777-935 samples)
- Mean, 95th and 5th percentiles

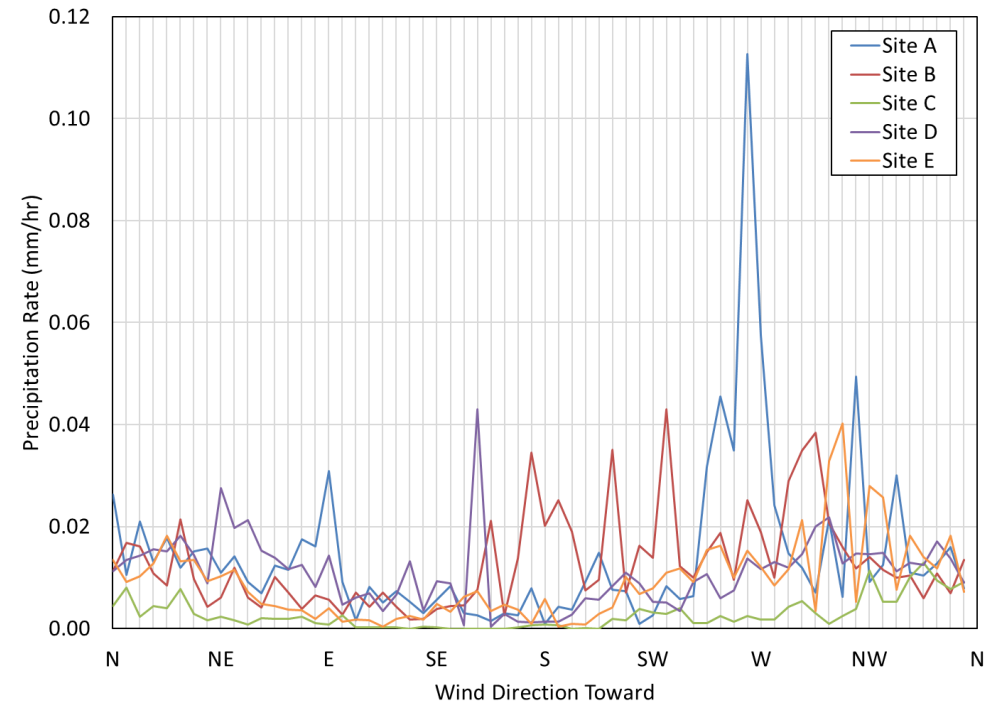


NAM 12-km meteorological
 database - 2008
 DTDZ stability class method

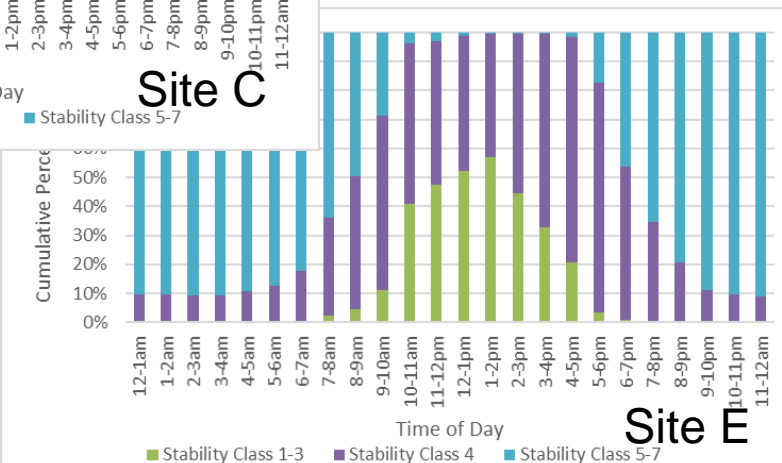
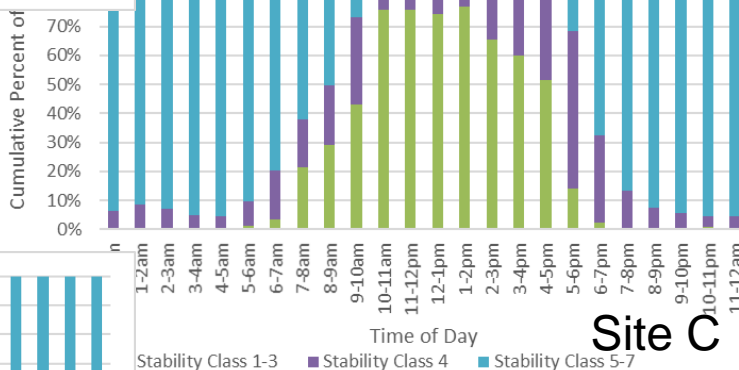
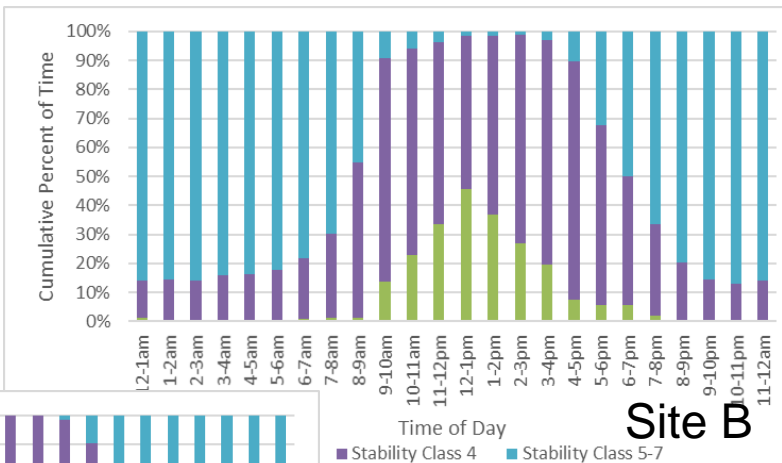




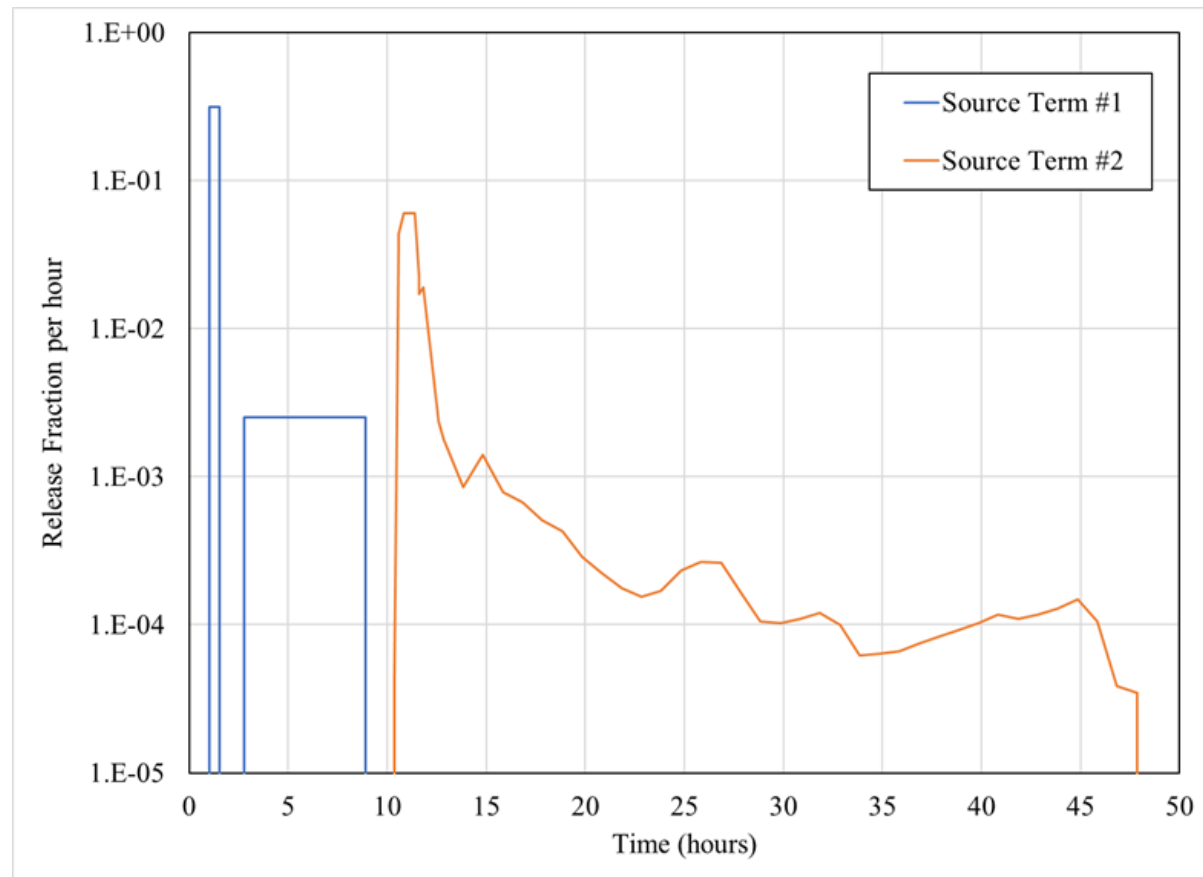
NAM 12-km meteorological
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DTDZ stability class method



Meteorology (cont.)



- Source Term #1 - NUREG-1150 historic (puff release followed by a longer duration tail)
- Source Term #2 - SOARCA Short-Term Station Blackout (more delayed and prolonged)



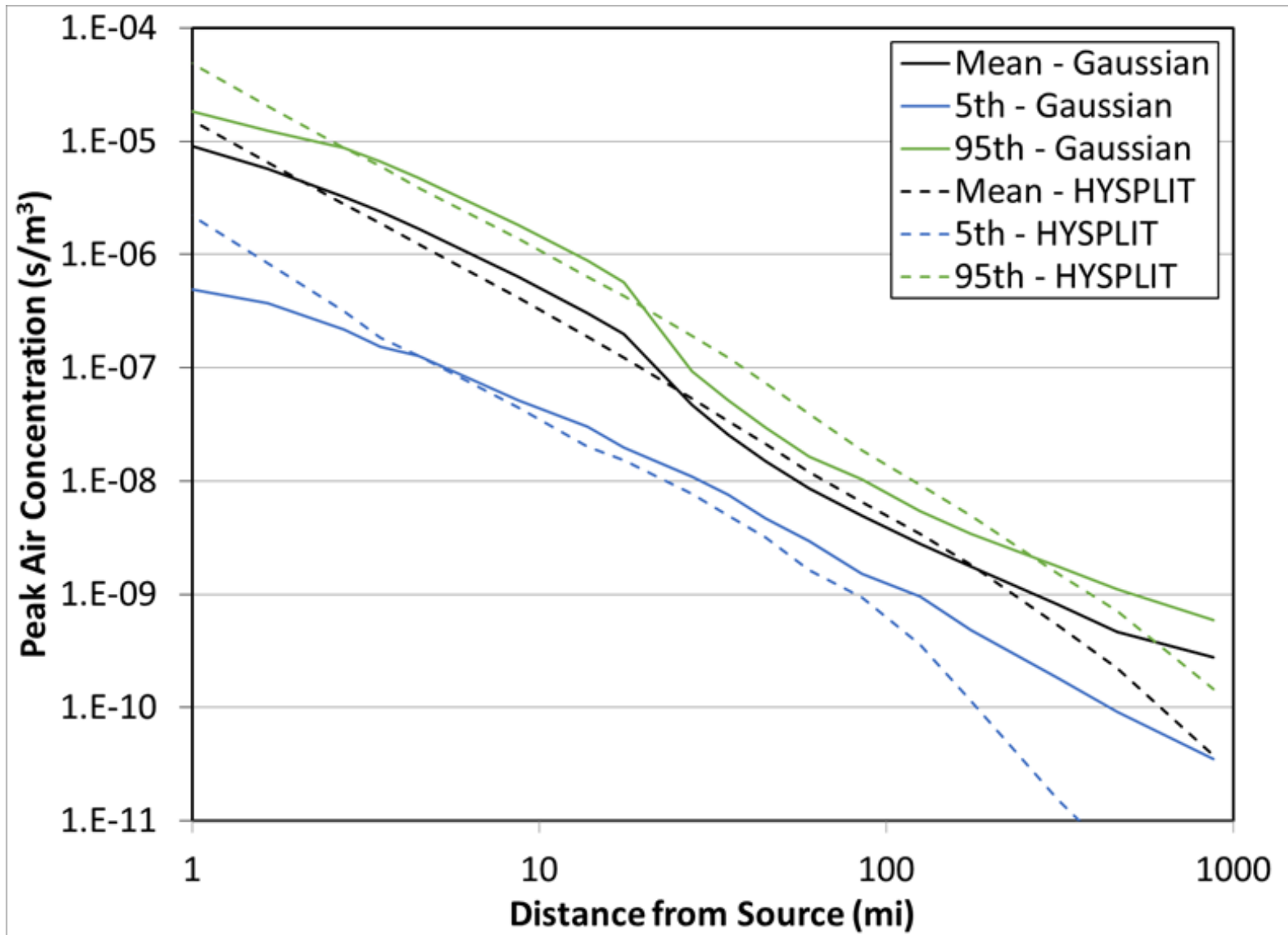
- Peak (around the compass) time-integrated air concentration (χ/Q , s/m³)
- Peak (around the compass) ground deposition (D/Q, 1/m²)
- Normalized peak dose (unitless)
- Normalized population-weighted early fatality risk within a circular area near the point of release
- Normalized regional population doses
- Normalized population-weighted latent cancer fatality risk over region
- Normalized land areas that exceed various levels of contamination
- Normalized total regional economic losses

- Large River Valley
 - Comparison #1 - NUREG-1150 source term
 - HYSPLIT/Gaussian
 - Comparison #2 - SOARCA, STSBO Source Term
 - HYSPLIT/Gaussian

- Near and far field summary of all sites

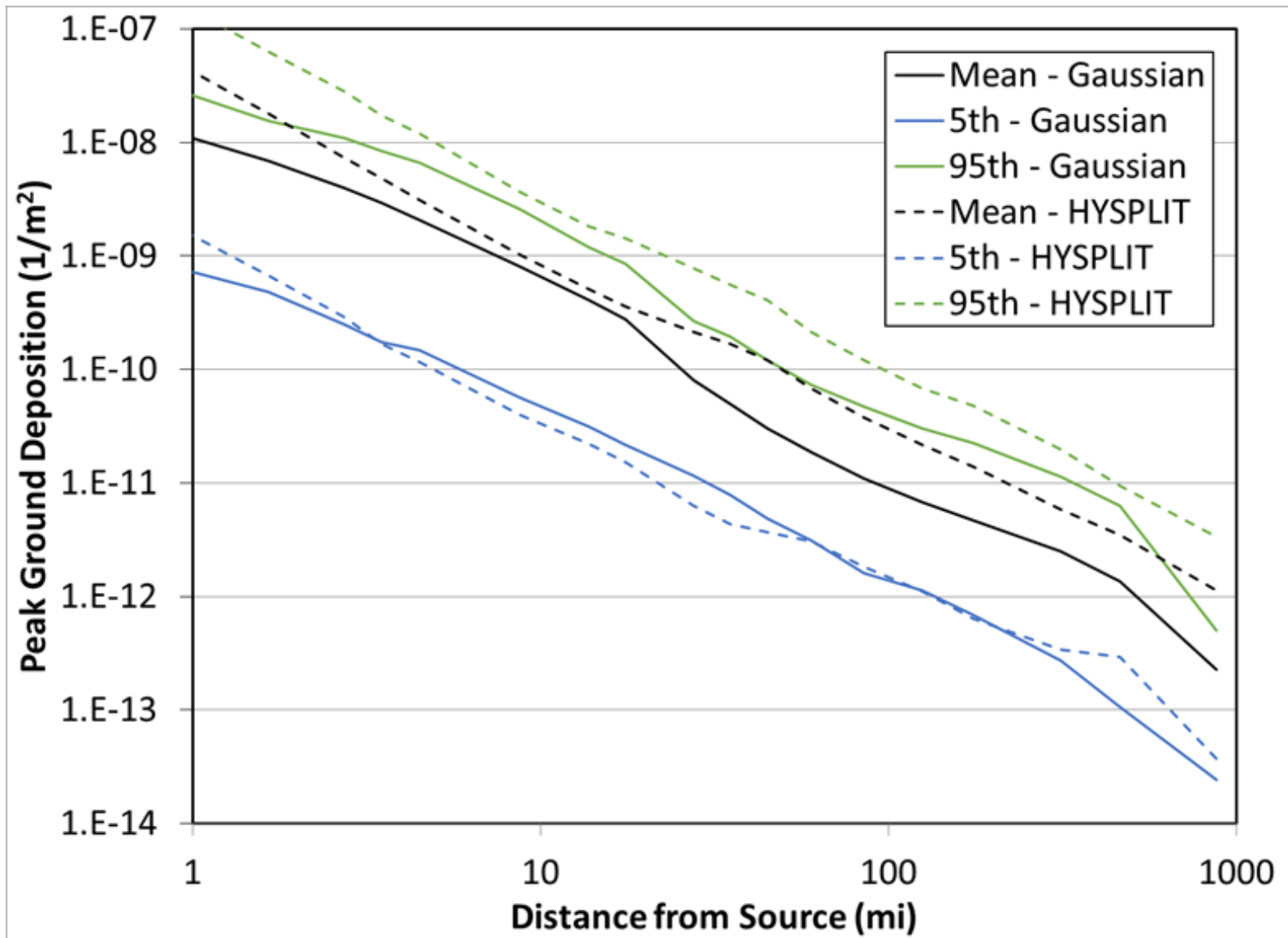
Comparison #1 Peak Air Concentration

(Large River Valley, NUREG-1150 Source Term, HYSPLIT/Gaussian)



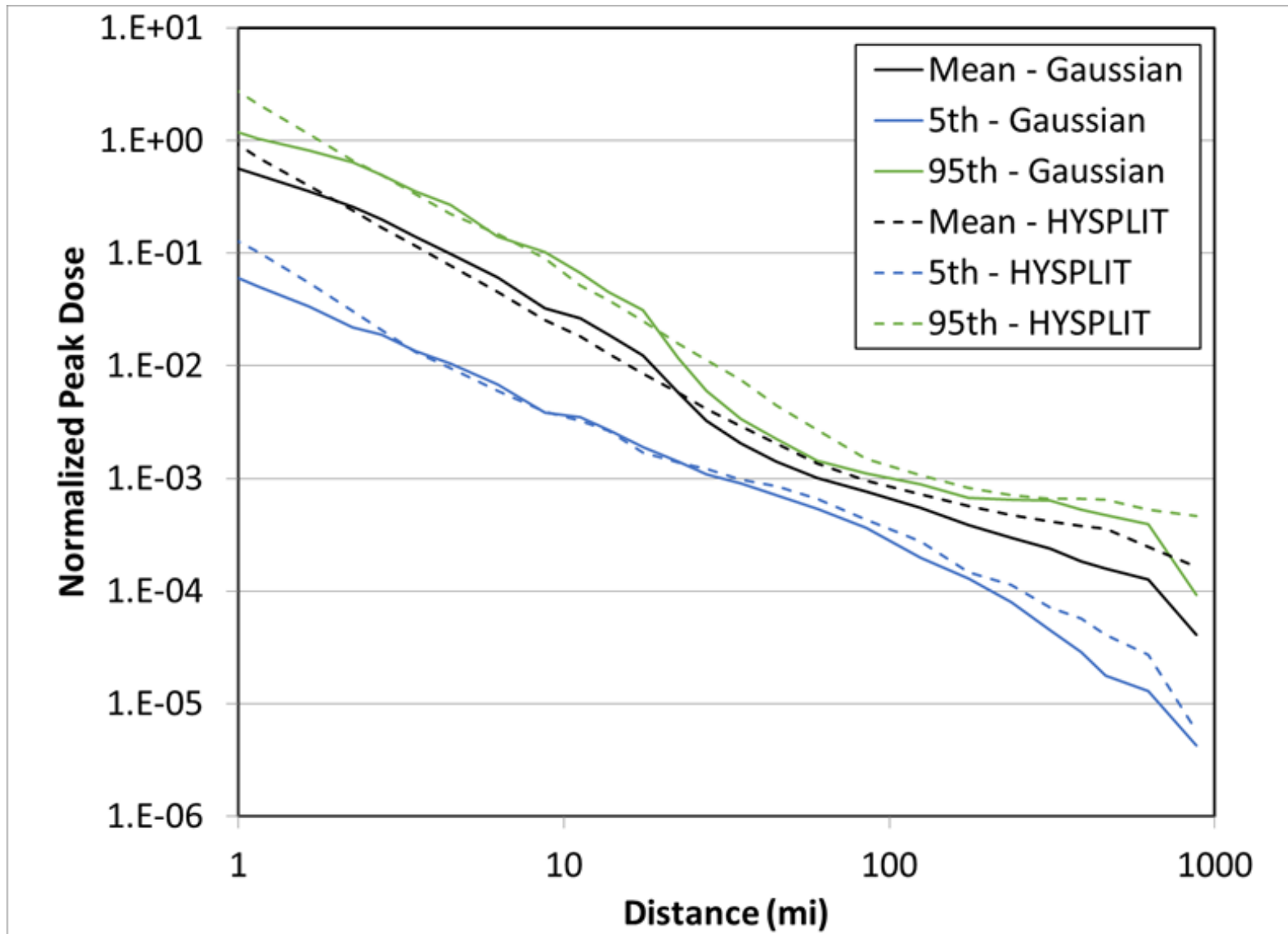
Comparison #1 Peak Ground Deposition

(Large River Valley, NUREG-1150 Source Term, HYSPLIT/Gaussian)



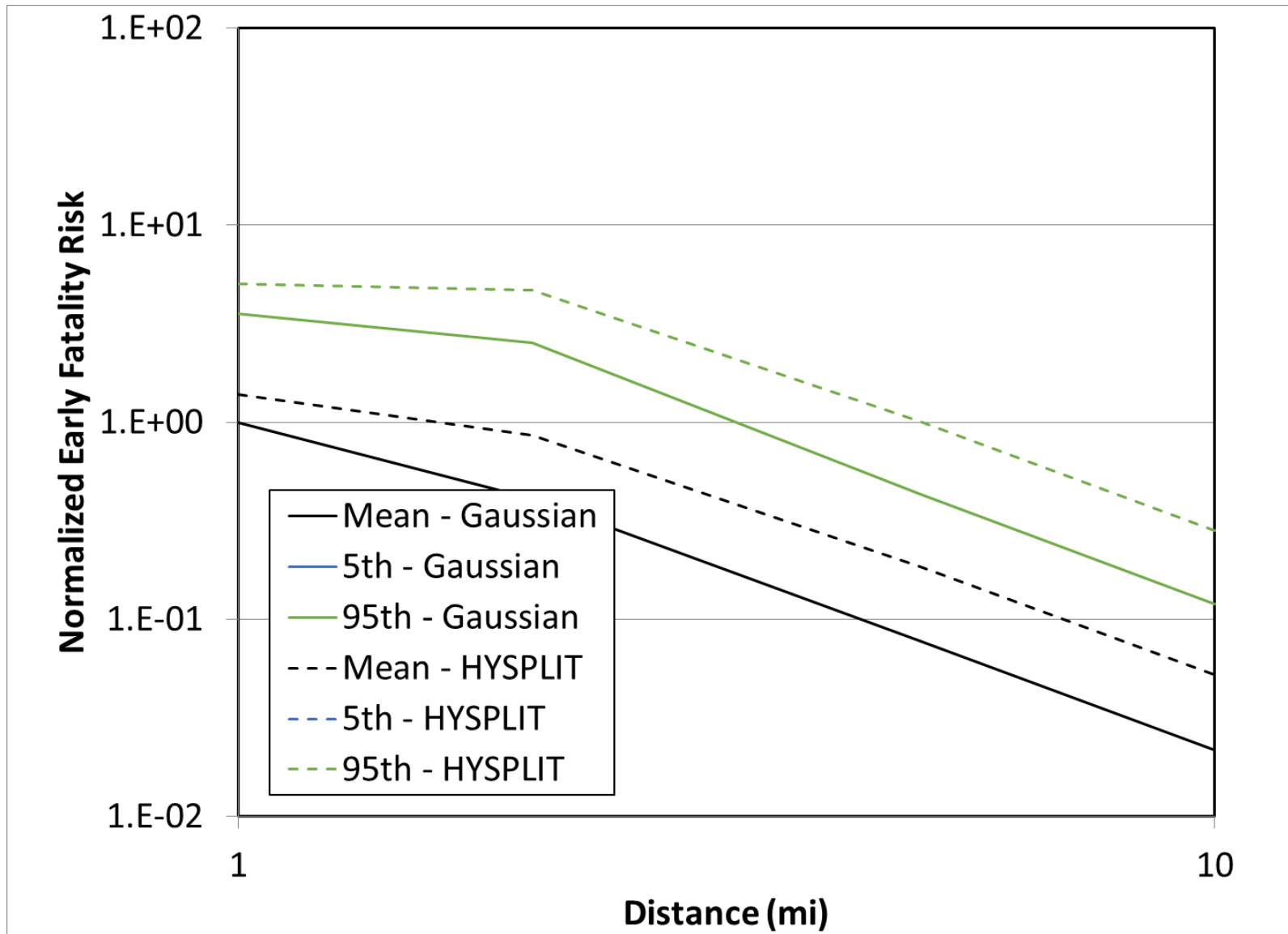
Comparison #1 Peak Dose

(Large River Valley, NUREG-1150 Source Term, HYSPLIT/Gaussian)



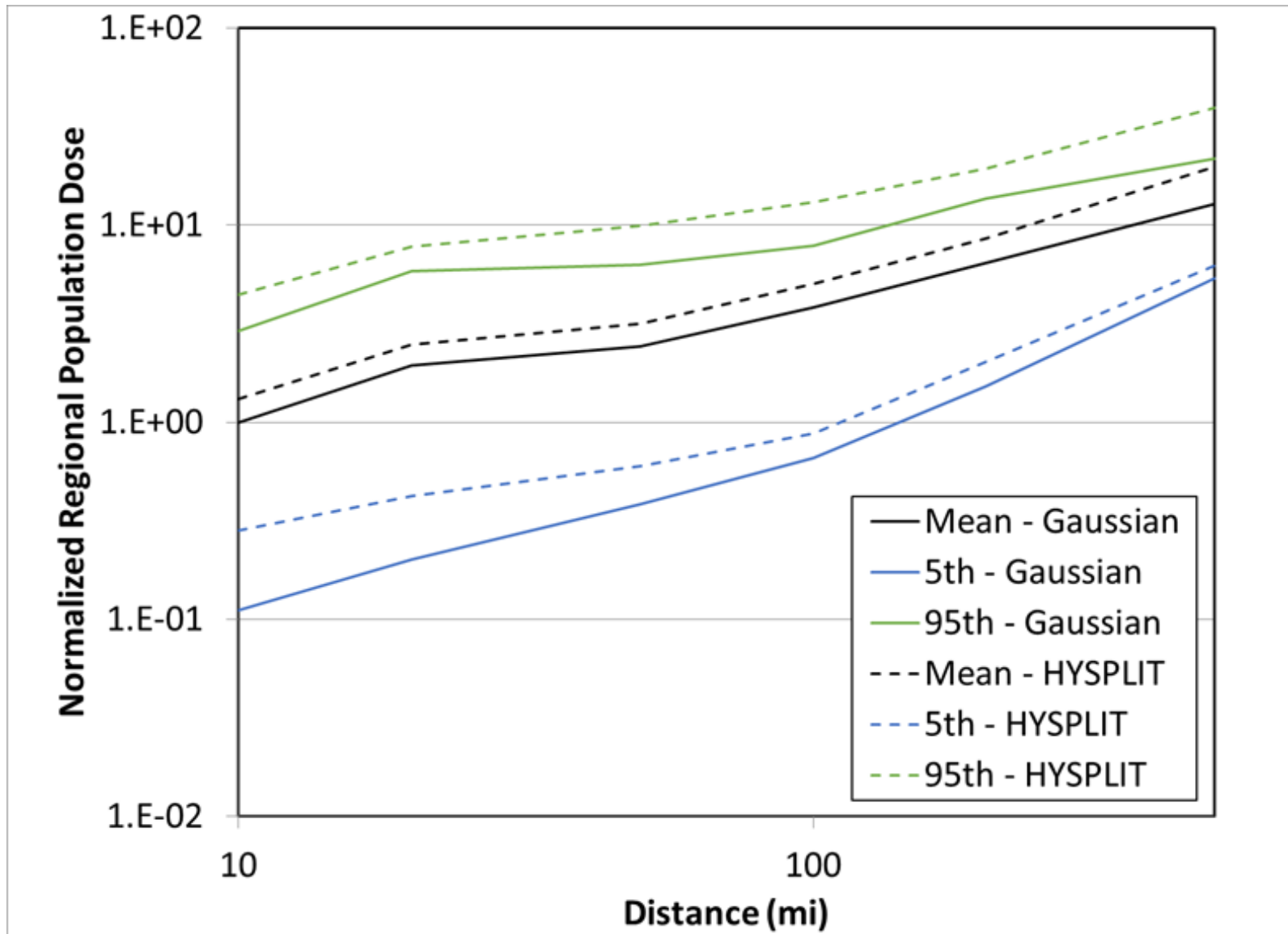
Comparison #1 Early Fatality Risk

(Large River Valley, NUREG-1150 Source Term, HYSPLIT/Gaussian)



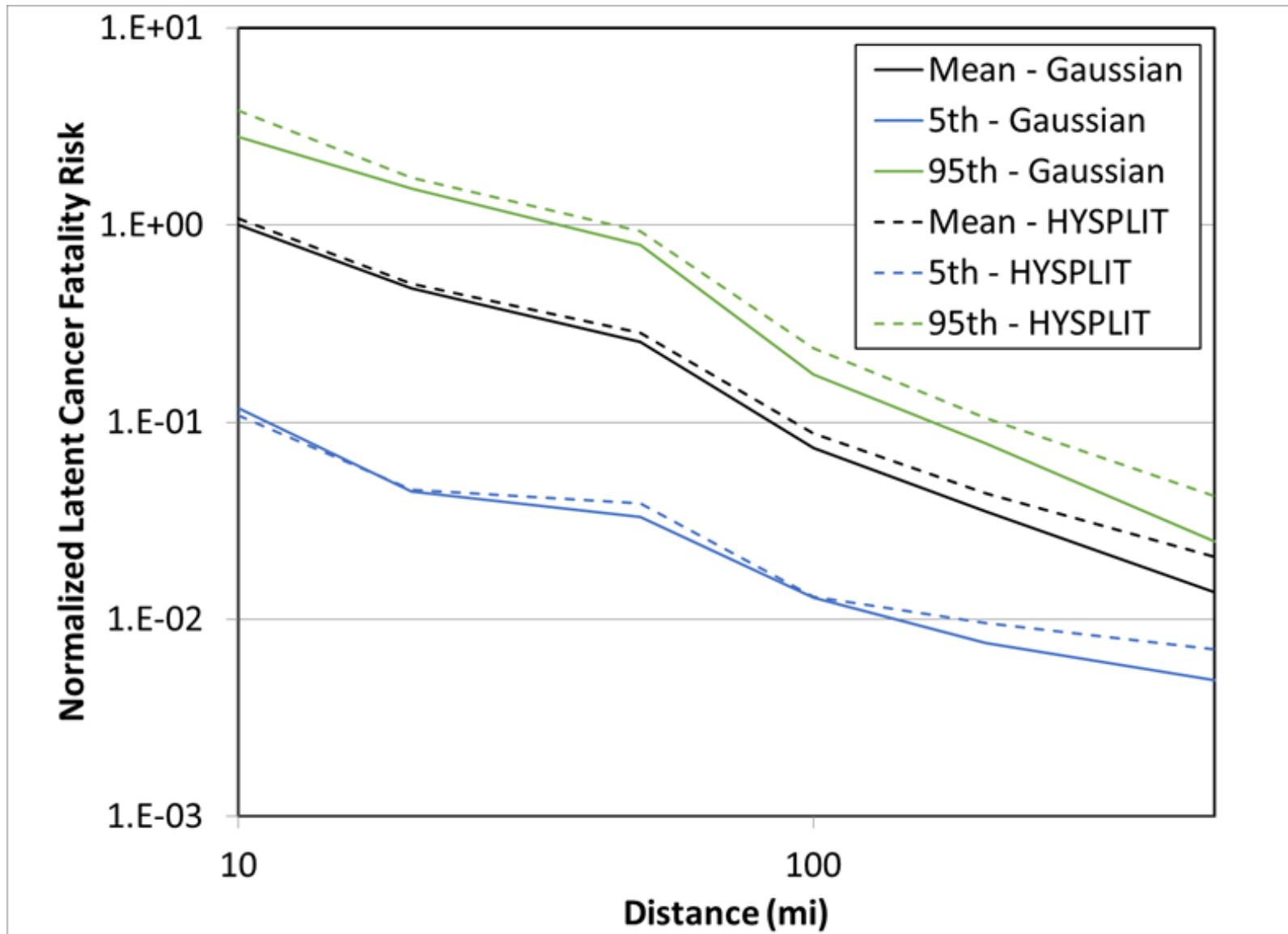
Comparison #1 Population Dose

(Large River Valley, NUREG-1150 Source Term, HYSPLIT/Gaussian)



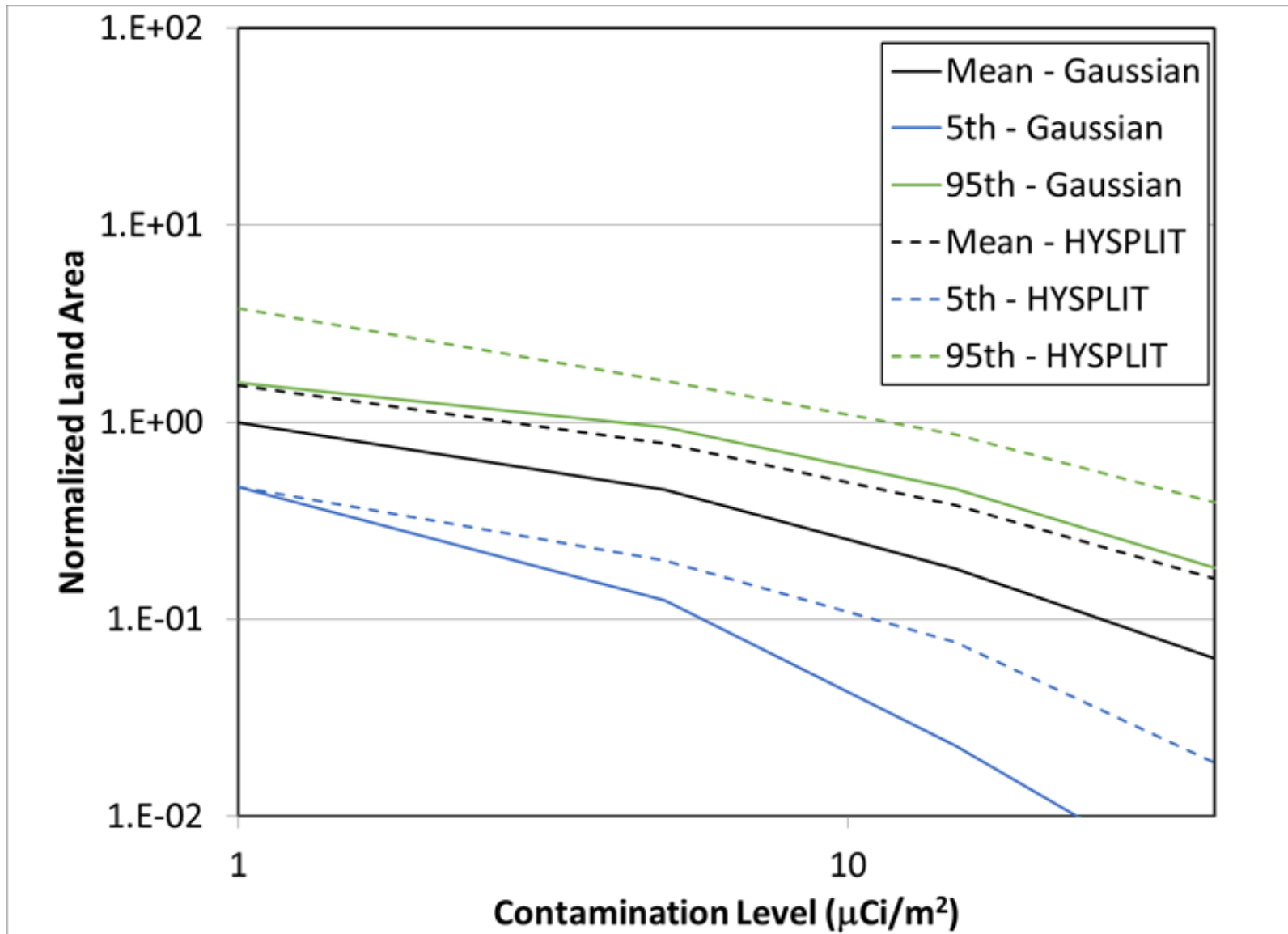
Comparison #1 Latent Cancer Fatality Risk

(Large River Valley, NUREG-1150 Source Term, HYSPLIT/Gaussian)



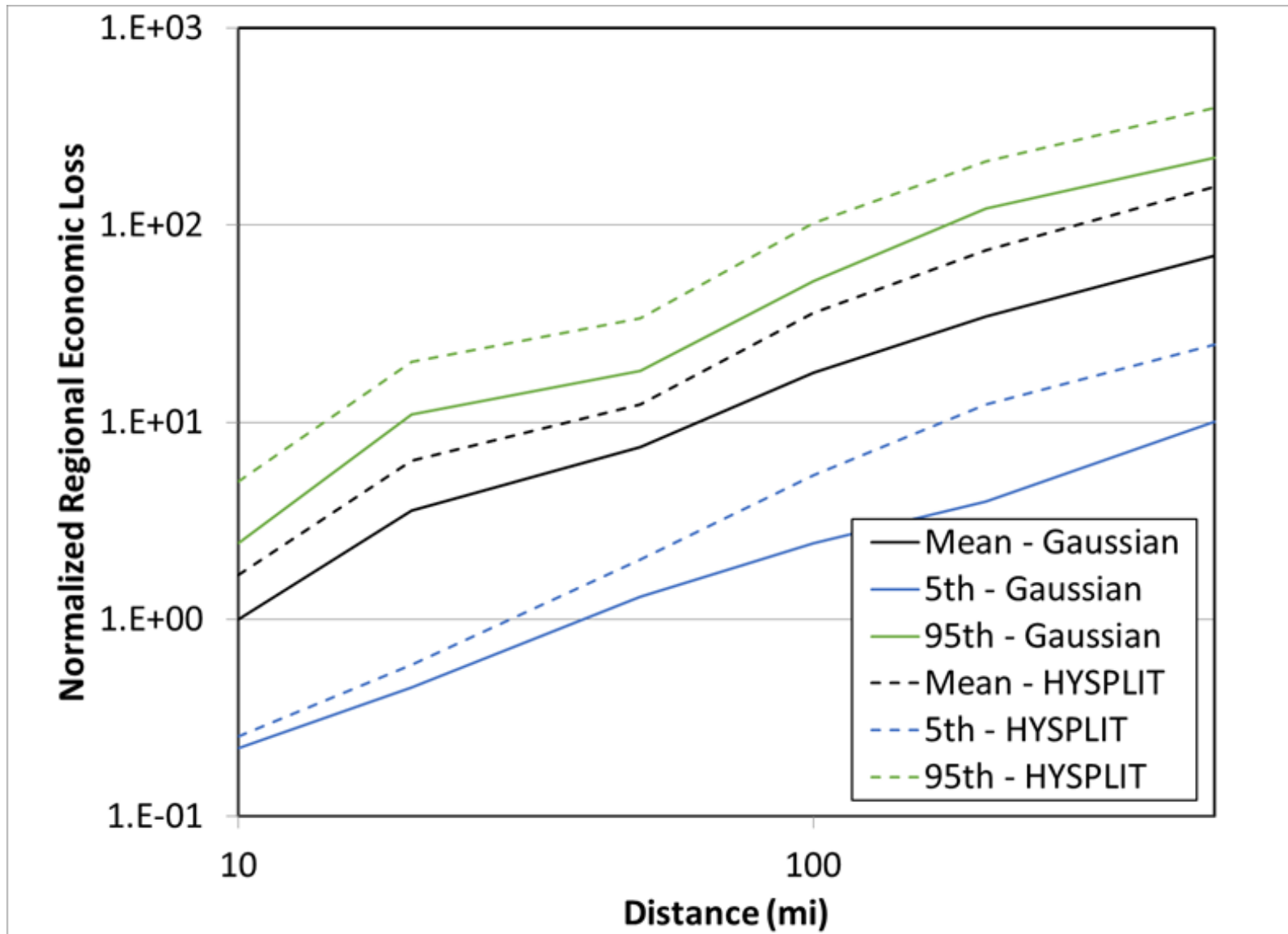
Comparison #1 Land Contamination Area

(Large River Valley, NUREG-1150 Source Term, HYSPLIT/Gaussian)



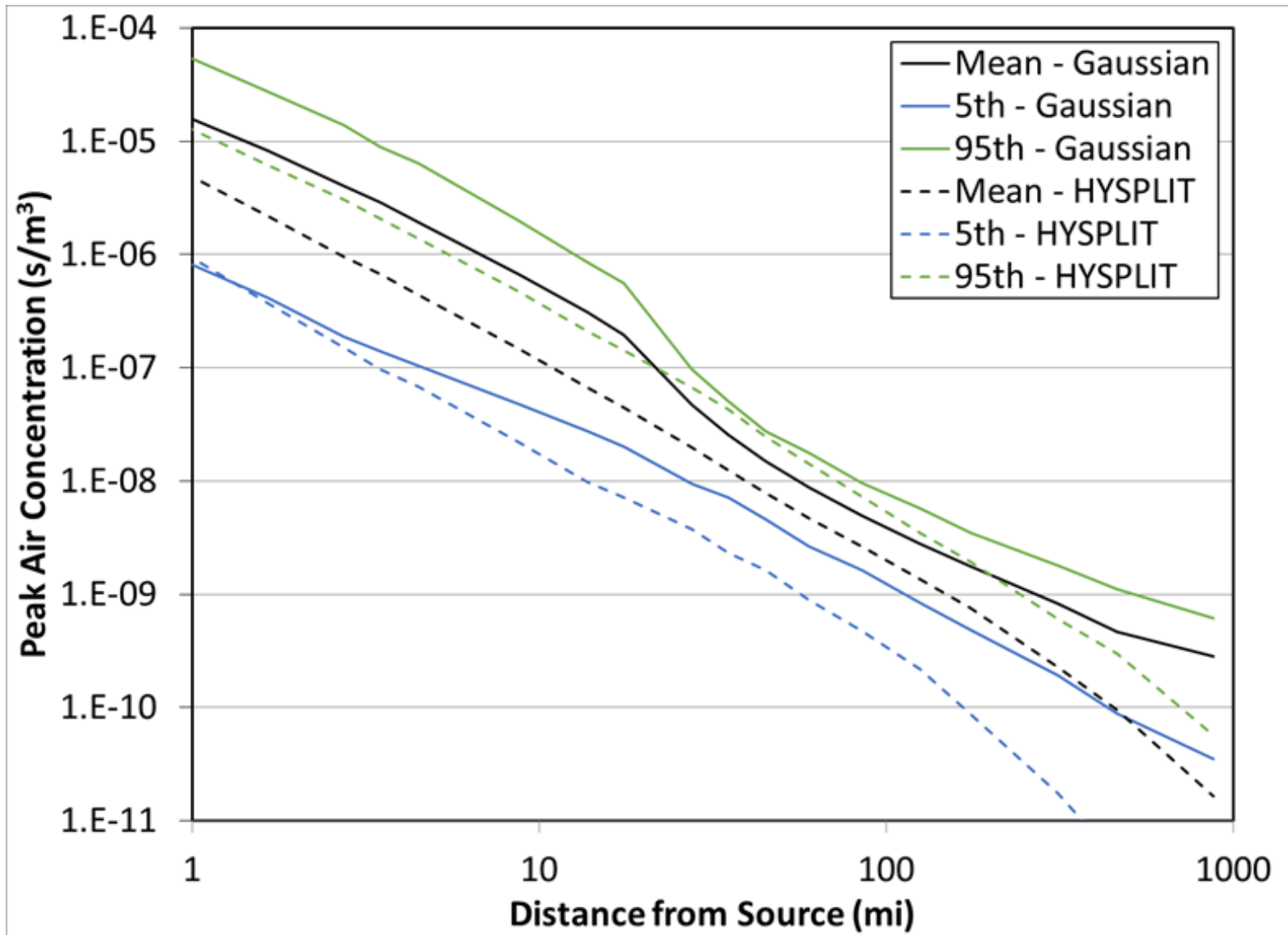
Comparison #1 Economic Loss

(Large River Valley, NUREG-1150 Source Term, HYSPLIT/Gaussian)



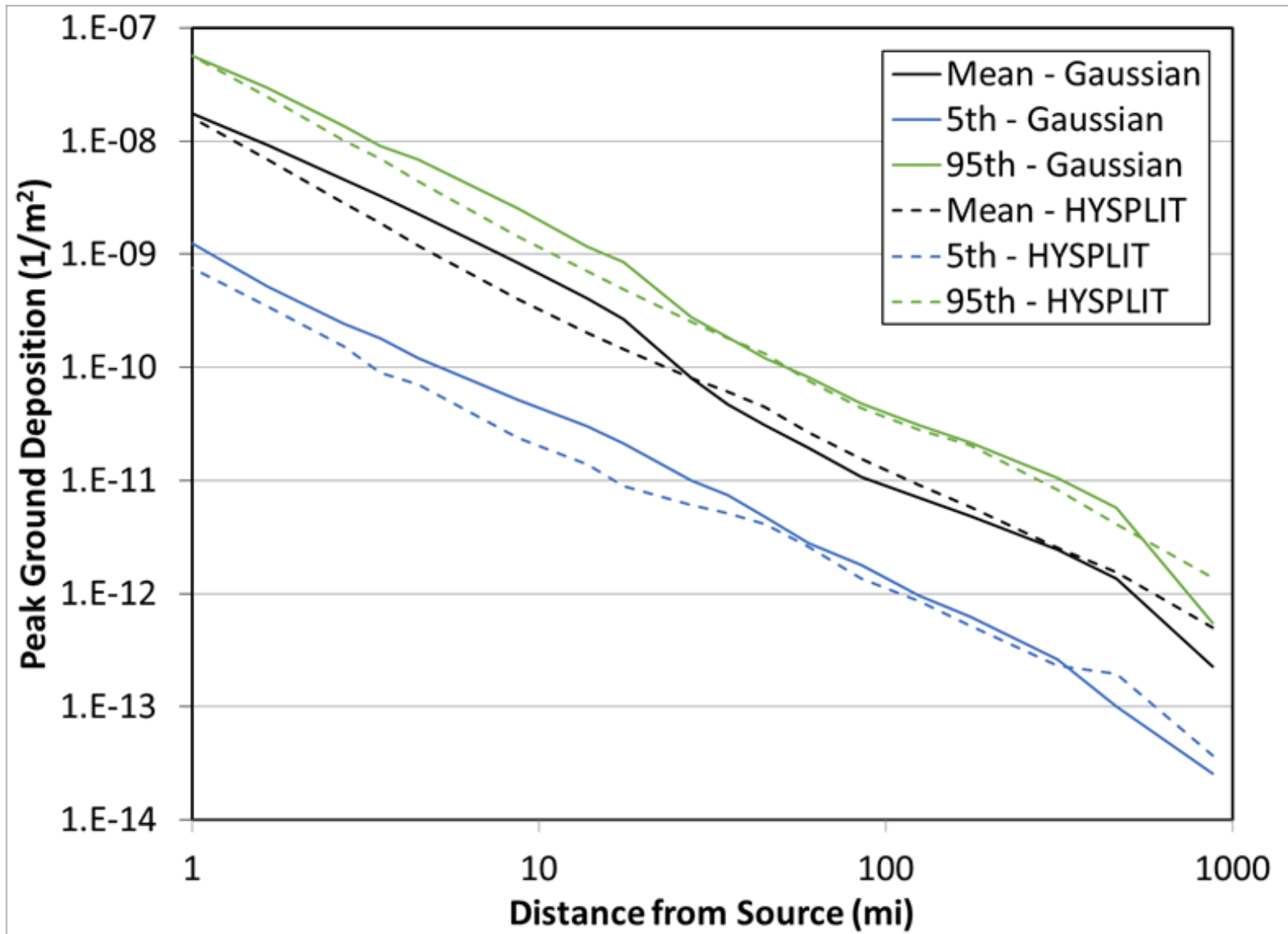
Comparison #2 Peak Air Concentration

(Large River Valley, STSBO Source Term, HYSPLIT/Gaussian)



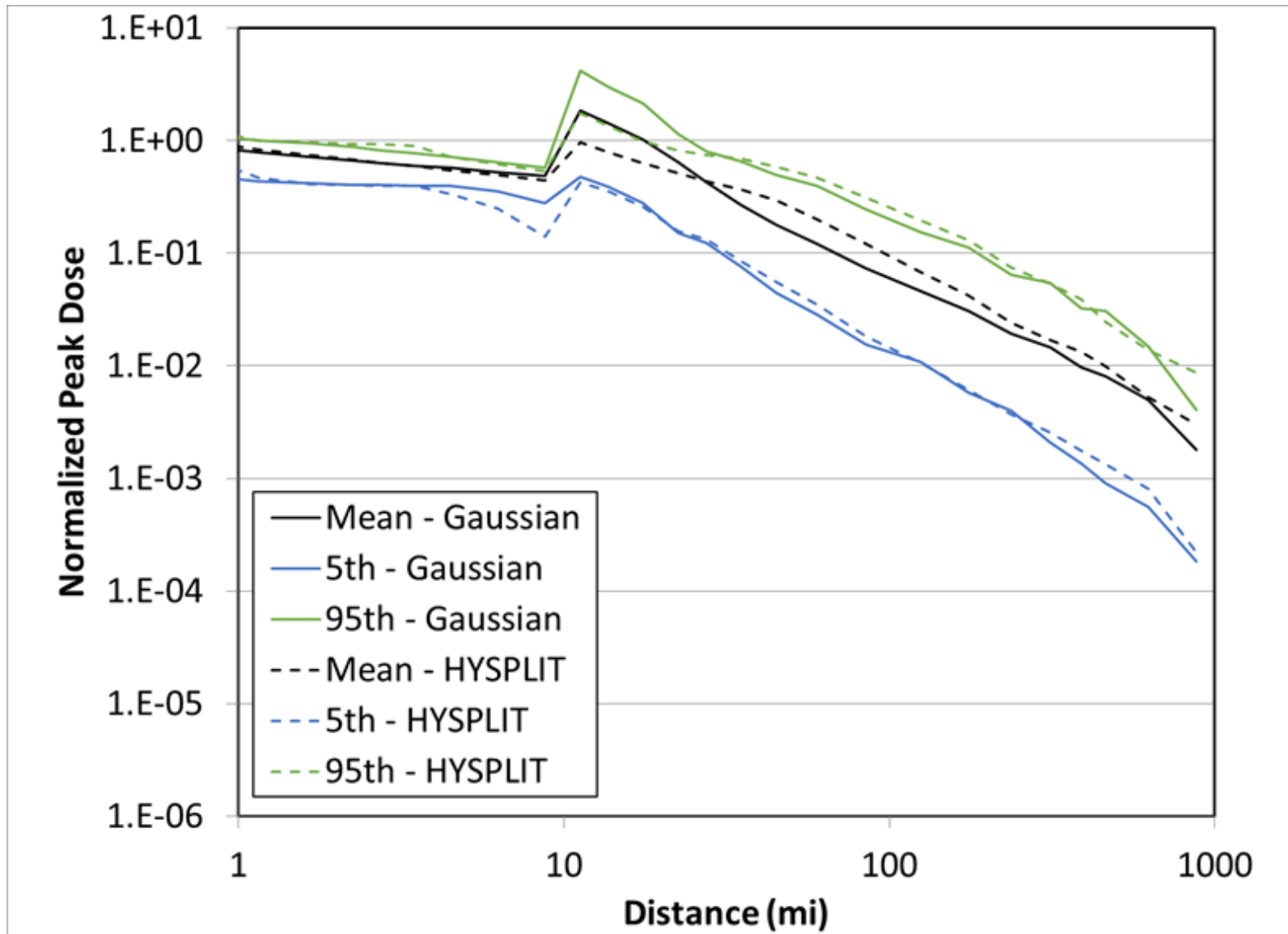
Comparison #2 Peak Ground Deposition

(Large River Valley, STSBO Source Term, HYSPLIT/Gaussian)



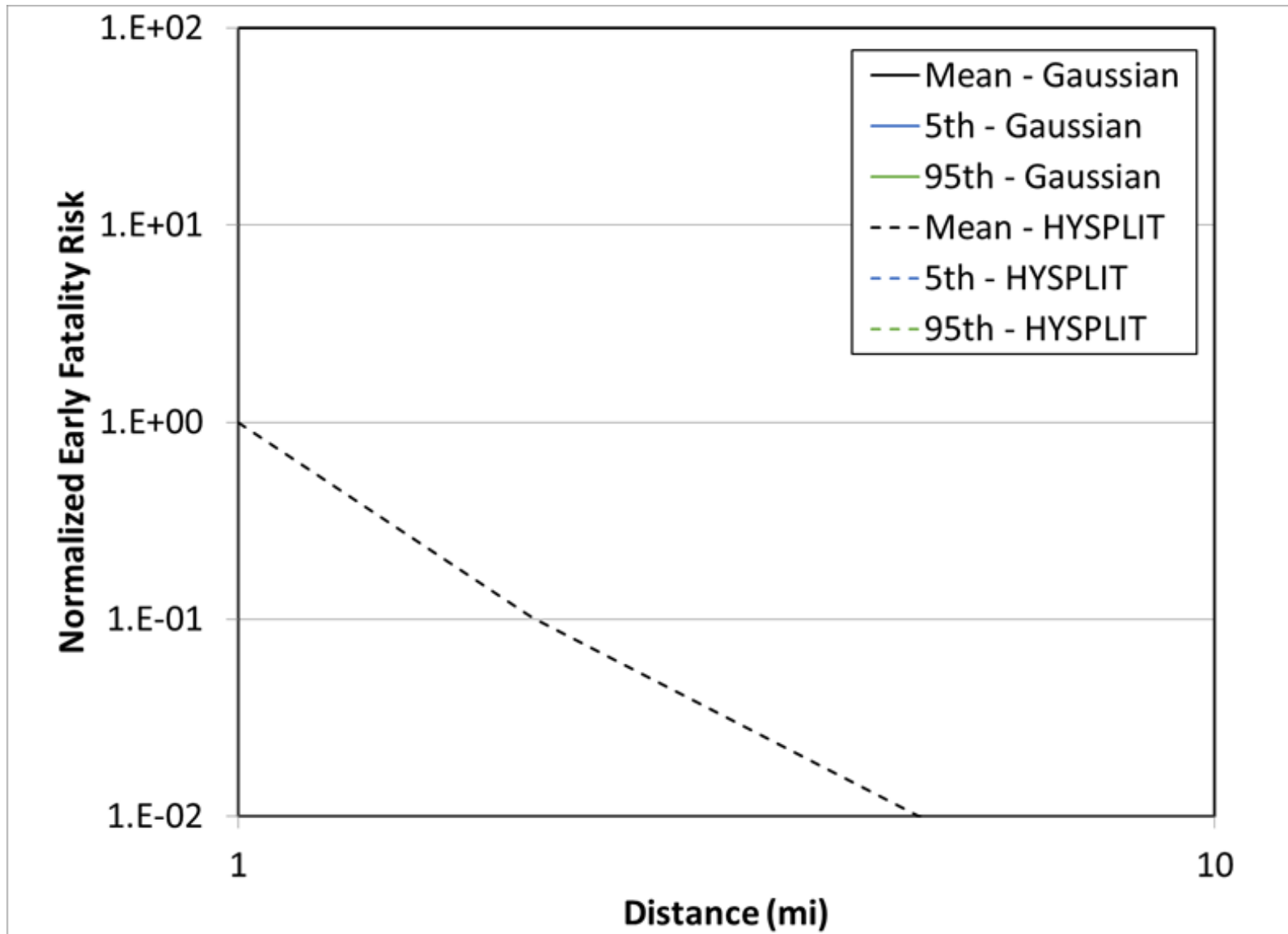
Comparison #2 Peak Dose

(Large River Valley, STSBO Source Term, HYSPLIT/Gaussian)



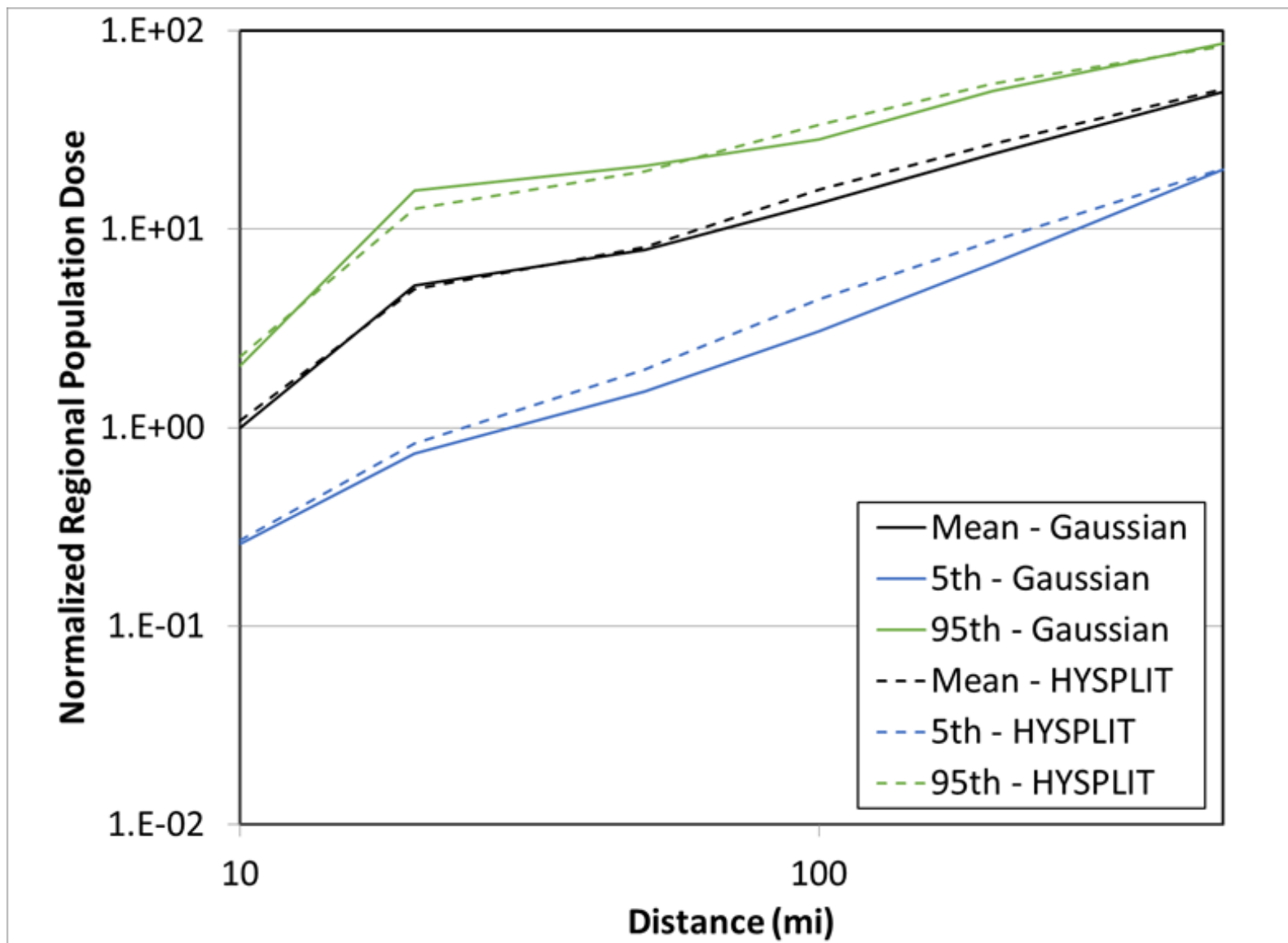
Comparison #2 Early Fatality Risk

(Large River Valley, STSBO Source Term, HYSPLIT/Gaussian)



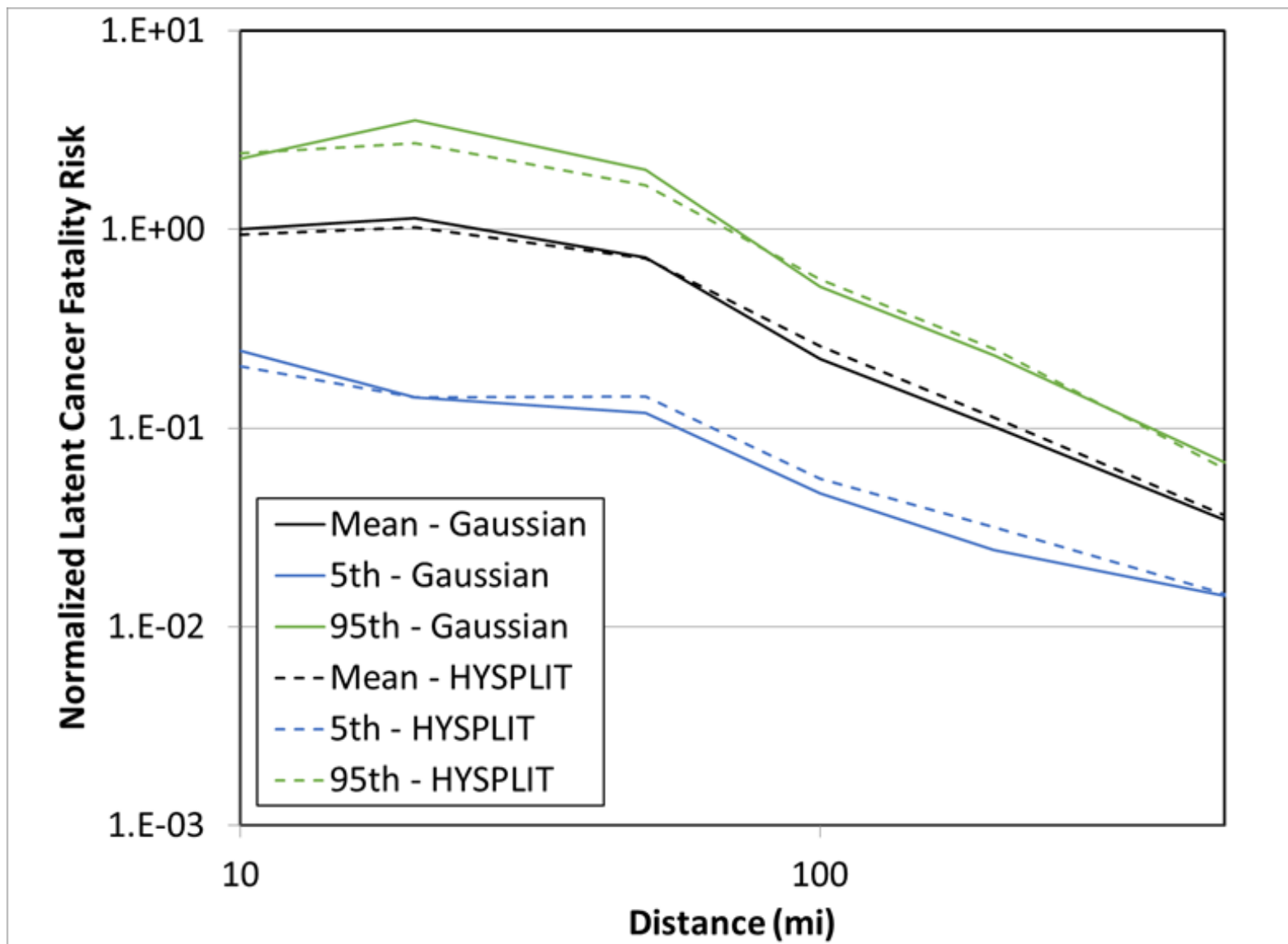
Comparison #2 Population Dose

(Large River Valley, STSBO Source Term, HYSPLIT/Gaussian)



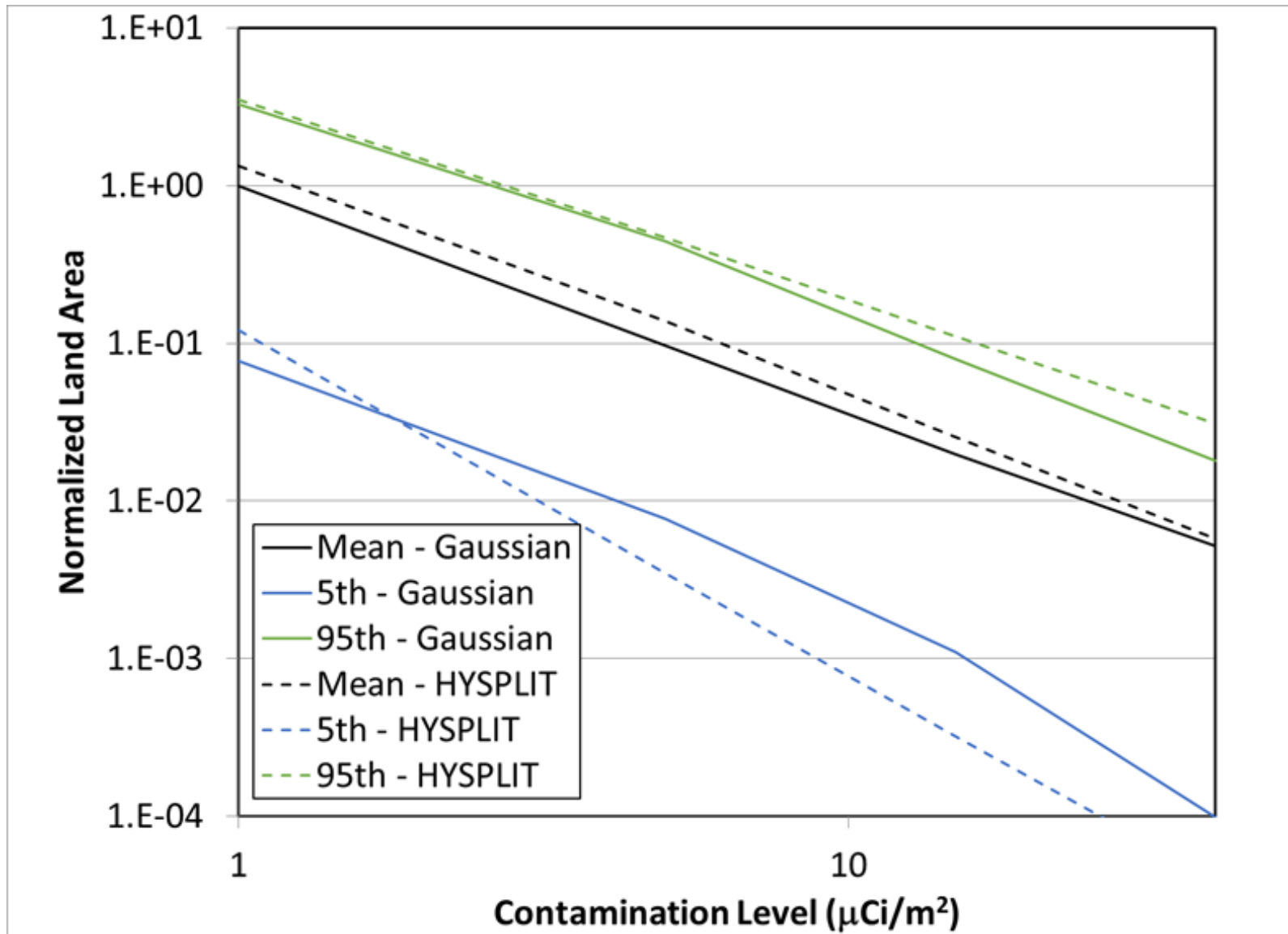
Comparison #2 Latent Cancer Fatality Risk

(Large River Valley, STSBO Source Term, HYSPLIT/Gaussian)



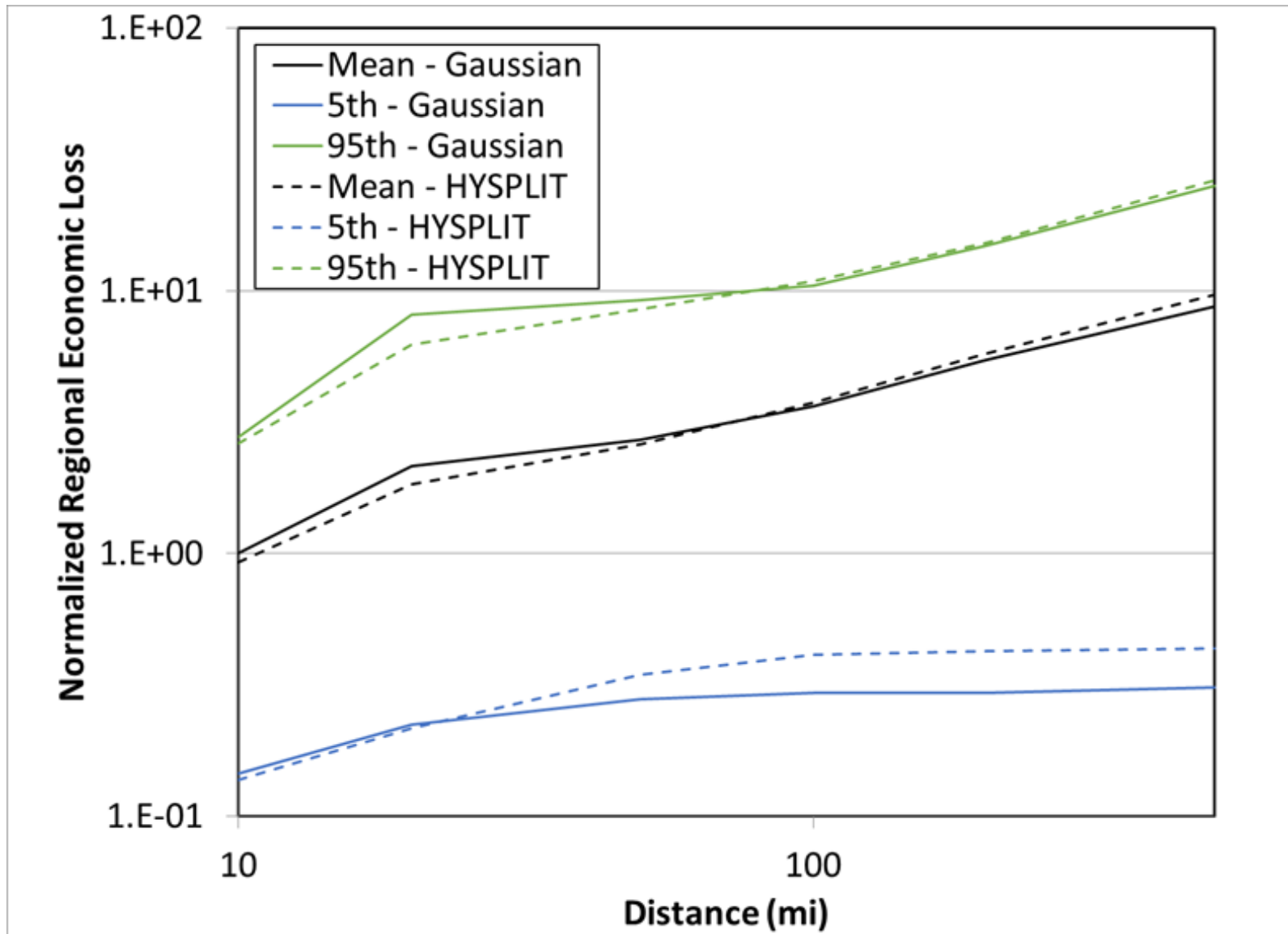
Comparison #2 Land Contamination Area

(Large River Valley, STSBO Source Term, HYSPLIT/Gaussian)



Comparison #2 Economic Loss

(Large River Valley, STSBO Source Term, HYSPLIT/Gaussian)



- Gaussian model compared with the HYSPLIT model
 - + indicates Gaussian larger
 - 0 indicates Gaussian & HYSPLIT nearly the same
 - – indicates Gaussian lower
 - -+ indicates Gaussian lower closer in and larger further out.
- Near field trends influenced by source term nature and site
- Far field trends consistent across sites and source terms

Site/Source	Near Field								Far Field					
	peak air	peak ground	peak dose	pop dose	LCF risk	Econ Loss	EF risk	Land Area	peak air	peak ground	peak dose	pop dose	LCF risk	Econ Loss
A/1	-+	-	-+	-	-	-	-	-	-+	-	-	-	-	-
A/2	+	+	+	0	+	+	0	-	+	-	-	-	-	-
B/1	-+	-	-+	-	-	-	-	-	-+	-	-	-	-	-
B/2	+	-+	+	-	-	-	0	-	+	0	-	-	-	-
C/1	-+	+	0	-	0	-	-	-	-+	-	-	-	-	-
C/2	+	+	+	+	+	+	0	-	+	-	-	-	-	-
D/1	-	-	-	-	-	-	-	-	-+	-	-	-	-	-
D/2	+	0	+	-	-	-	0	-	+	-	-	-	-	-
E/1	-+	-	-+	-	-	-	-	-	-+	-	-	-	-	-
E/2	+	+	+	-	0	0	0	-	+	-	-	-	-	-

- The level of agreement between the Gaussian and HYSPLIT ATD model results was very good for the five sites, two source terms, and all output quantities that were evaluated
 - Most output results were within a factor of two when comparing the Gaussian and HYSPLIT ATD model results
 - The trends as a function of distance for the output quantities also agree well between the two models
- The 5th and 95th percentile results also follow the same trends for the Gaussian and HYSPLIT ATD models
 - For the most part, these results are also within a factor of two for the two models
 - More frequently exceed a factor-of-two separation, as expected

■ GenHYSPLIT

- ~31,000 processor hours total per site (four sets of 8,760 = 35,040)
- Run on 120 Linux processors for 6-7 days
- Total disk space per site = 500-600 GB

■ HyGridConvert

- 24 processor hours per site
- Run on one Windows processor for 24 hours
- Total disk space per site = 200 GB

- **MACCS**
 - NUREG-1150 source term
 - Run on one Windows processor
 - Gaussian ADT model, ~2 processor minutes per site
 - HYSPLIT ADT model, ~20 processor hours per site (600 times longer)
 - SOARCA, Short-Term Station Blackout (STSBO)
 - Run on one Windows processor
 - Gaussian ADT model, ~30 processor minutes per site
 - HYSPLIT ADT model, ~130 processor hours per site (260 times longer)

- Integration of HYSPLIT results with MACCS complete
- Supplements Gaussian plume segment model in MACCS
- Benchmark analysis performed over wide set of metrics and distances
 - Five sites
 - Two source terms
- High level of agreement between the Gaussian and HYSPLIT analyses
- Need to balance the need for higher fidelity models with associated higher computational costs