GENII Version 2
General Purpose Environmental Radiation Software

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GENII Overview

A set of computer programs for estimation of radionuclide concentrations in the environment and dose/risk to humans from:

- Acute or chronic exposures from
- Radiological releases to the atmosphere, surface water, or
- Initial contamination conditions

One of a set of quality-assured and configuration-controlled safety analysis codes managed and maintained for DOE’s Safety Software Central Registry
GENII Development History

- 1988 - Version 1. Released
  - ICRP-26/30/48 dosimetry
- 1990 - Version 1.485 stabilized
- 1992 - GENII-S stochastic version
- 2004 - GENII Version 2
  - ICRP-72 age-dependent dosimetry
  - EPA HEAST slope factors
  - Federal Guidance Report 13 risk factors
- 2006/7 – V&V
- 2008 – New features, DOE toolbox status
Available Models in GENII

- Atmospheric transport
- Surface water transport
- Waste/soil redistribution
- Terrestrial uptake
- Human Exposure
- Dose/Risk
- Uncertainty/Sensitivity
Types of Scenarios

► Far-Field scenarios
  ■ Atmospheric transport (acute or chronic)
  ■ Surface water transport (acute or chronic)

► Near-Field scenarios
  ■ Spills
  ■ Buried waste
  ■ Groundwater use - groundwater transport modeling is NOT an explicit part of GENII
GENII V.2 Time Line

- **Dose Period**
  - Release Period
    - Optional inventory
      - decay/biotic transport period
  - Residual Period
    - Intake/exposure begins
    - Release stops
    - Intake/exposure ends

- Release or disposal
  - Release begins
  - Intake/exposure begins
Radionuclides of Interest

- All those with half-lives greater than 10 minutes, except radon progeny
- And all decay progeny
  - Some are included “implicitly” with the parent radionuclide
GENII V.2 Atmospheric Transport Options

- Chronic
  - Gaussian Plume
  - Lagrangian Puff
- Acute
  - Gaussian Plume
  - Lagrangian Puff
- Estimation of $95^{\text{th}}$ percentile dispersion conditions
- Input of pre-calculated dispersion parameters
GENII V.2 Chronic Plume Model

- Straight-line, sector-averaged Gaussian plume model
  - Uses hourly observations or joint-frequency data
  - Multiple, independent sources
    - Ground level or elevated releases
    - Point or area sources
    - Finite flow correction
  - Sectors by 16 compass points or 10 degrees
  - Radial output grid
GENII V.2 Chronic Puff Model

- Lagrangian puff releases based on a single meteorological station
  - Hourly time step (variable number of puffs/hour) using hourly observations or quasi-hourly built from joint-frequency data
  - Cartesian (rectangular) grid
  - Multiple sources
    - Point or area sources
    - Ground level or elevated releases
GENII V.2 Acute Plume Model

- Straight-line centerline Gaussian for individuals
  - For short (~2 hour releases)
  - Single source
  - Ground-level or elevated releases

- Radial grid
  - Radial sectors by 16 compass points or 10 degrees

- A specialized module for 95th percentile conditions is now available (currently NOT the NRC RG 1.145 approach for sector and site, but could be revised)
GENII V.2 Acute Puff Model

- Lagrangian puff based on a single meteorological station
  - Hourly time step using hourly observations or quasi-hourly inputs derived from joint-frequency data
  - Single source
  - Cartesian (rectangular) grid
  - Ground-level or elevated releases
Parameterizations for Diffusion Coefficients

- Briggs open country
- Briggs urban conditions
- Pasquill-Gifford (ISC-3)
- Pasquill-Gifford (NRC: PAVAN, MESORAD, XOQDOQ)
- Turbulence Statistics (NRC: RASCAL)
Parameterizations Available in All Dispersion Models

- Building wake/low-speed meander correction to diffusion
- Buoyancy-induced diffusion
- Plume rise/downwash corrections
  - Momentum
  - Buoyancy
- Diabatic wind profile
GENII V.2 Atmospheric Deposition

- All models have plume depletion/mass balance
- Dry deposition
  - “Resistance model”
  - Includes gravitational settling of larger particles
- Wet deposition
  - Washout dependent on precipitation rate
  - Rain and snow considered
Sources of Meteorological Data for Atmospheric Models

► Hourly data
  ■ CD-144 format (National Climatic Data Center - NCDC)
  ■ SAMSON format (NCDC)
  ■ Precipitation in TD-3240 format (NCDC)

► Joint frequency data
  ■ STAR (ISC-3) [provided for many US sites]
  ■ GENIIT V.1.485
GENII V.2 Air Submersion Dose Rates

- **Infinite plume**
  - Based on Federal Guidance Report FGR-13 models

- **Finite plume**
  - Close to release - array of line sources
  - Intermediate distances - stacked series of infinite planes
  - Long distances - defaults to infinite plume
GENII V.2 Surface Water Transport Models

Simple models derived from NRC’s LADTAP

- Rivers: analog to atmospheric Gaussian plume
  - Constant depth, width, velocity
  - Straight channel
  - Continuous discharge
- River - dilution volume (well mixed)
- Acute river (time integral)
- Lake
  - quasi-steady state wind-driven currents
GENII V.2 Near-Field Biotic Transport

- Plant roots - root fraction applied to concentration ratio (CR)
- Burrowing animals - volume of soil moved versus depth
- Applied to arid, humid, or agricultural conditions
GENII V.2 Near-Field Human Intrusion

- Buried waste and/or deep soil may be manually redistributed at the start of exposure to the surface soil.
- Process is a step function manual redistribution factor ($m^3/m^2$).
GENII V.2 Exposure Pathways

External
- Transported air
- Soil
- Swimming
- Shoreline

Inhalation
- Transported air
- Resuspended soil
- Volatilized indoor air pollutants from water
GENII V.2 Exposure Pathways, Continued

**Ingestion**
- Leafy vegetables
- Other vegetables
- Fruit
- Grain
- Meat
- Milk
- Poultry
- Eggs
- Fish
- Crustaceans
- Molluscs
- Water plants
- Drinking water
- Shower water
- Swimming water
- Soil
GENII V.2 Crop Contamination

▶ Plant = Soil \* CR + intercepted deposition

- Concentration ratios (CR) are traceable to current U.S. and international literature (PNNL-21950).
- Interception function of crop biomass
  - Wet interception
  - Dry interception
Animal Product = TF \sum (Crop \times \text{Ingestion rate})

- Transfer factors (TF) are traceable to current U.S. and international literature (PNNL-21950).
Fish = Water concentration * BF

Bioaccumulation factors (BF) are traceable to current U.S. and international literature (PNNL-21950).
GENII V.2 Tritium Specific Activity Model

- Environmental media assumed to have same specific activity (Bq/kg water) as contaminating medium (water or air)
- Fractional content of both water and non-water portions of the food product is used
- In acute cases, rapid equilibration/de-equilibration is assumed (~8 hours)
- Based on observations at Chalk River
GENII V.2 Carbon-14 Specific Activity Model

- For atmospheric sources, model is parallel to that for tritium
- For water sources, equilibration is assumed with soil carbon atom ratios
- For acute cases, uptake via photosynthesis is slow, long de-equilibration
## GENII V.2 Human Exposure

- Up to 6 age groups allowed, following ICRP-56,67,69

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Duration</th>
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<tbody>
<tr>
<td>3 months</td>
<td>0-1 year</td>
</tr>
<tr>
<td>1 year</td>
<td>1-2 year</td>
</tr>
<tr>
<td>5 year</td>
<td>2-7 year</td>
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<tr>
<td>10 year</td>
<td>8-12 year</td>
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<tr>
<td>15 year</td>
<td>13-17 year</td>
</tr>
<tr>
<td>20+ year</td>
<td>17-110 year</td>
</tr>
</tbody>
</table>
GENII V.2 presents results for 4 seasons (winter/spring/summer/autumn)

This is a surrogate for a complex set of underlying assumptions about plant growth, weathering, uptake, and time-to-harvest

Selection of season depends on meteorological input (this is related to the uncertainty capability)

Season definitions are a user input, because seasons below the equator are reversed!
External Exposure - Doses

- Dose rate conversion factors from Federal Guidance Report FGR-12, provided by Keith Eckerman, ORNL
  - Air Submersion
  - Water Immersion
  - Soil Plane
  - Soil Volume
Internal Exposure - Doses

- Effective dose equivalent: ICRP-30
  - Adult only
- Effective dose: ICRP-72
  - 6 age groups
  - 24 organs/tissues
  - Inhalation classes Fast (F), Medium (M), Slow (S)
Risk Calculations – Dose-to-Risk Conversions

- ICRP provides estimates of cancer incidence and mortality in relation to effective dose
  - ICRP-30 effective dose
  - ICRP-72 organ dose
- The BEIR VII report supports these values with minor revision
  - Risk = Dose (Sv) * Conversion (risk/Sv)
US Federal Guidance Report 13 provides coefficients for 15 cancer sites
- Inhalation (risk/Bq)
  - Inhalation classes F, M, S
- Ingestion (risk/Bq)
  - Accounts for different consumption patterns with age
    - Drinking water
    - Food crops
Parameter uncertainty and sensitivity may be addressed using the SUM$^3$ processor in FRAMES.

All non-control parameters are allowed to be varied, using description files to define ‘available’ parameters.

Acute atmospheric releases are an important subset. For these, SUM$^3$ is used to vary start times in the plume or puff models, allowing construction of the location or site cumulative dose/risk distribution function.
Questions?

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