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Overview of MACCS Status and Development

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Contents

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- Status of current development
- Ongoing model development
- Ongoing applications
- Summary

Purpose for MACCS

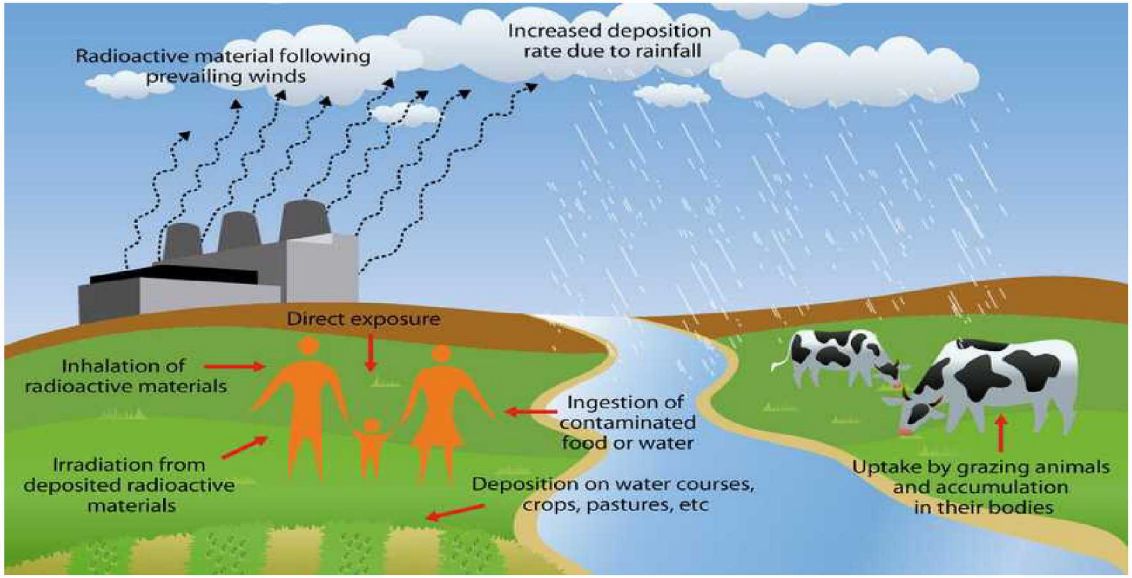
- Created by Sandia to support NRC research and regulatory applications
  - Origins go back to the mid-1970s
- Typically used for prospective analyses, e.g.,
  - Probabilistic risk assessments (NUREG-1150 and NRC's Level 3 PRA)
  - Probabilistic consequence assessments (SOARCA)
  - Cost/benefit analyses (required for environmental analyses in licensing)
- Very versatile with a large set of user inputs
- Intended to run rapidly for PRA applications
  - Large set of weather trials (hundreds or thousands)
  - Significant set of source term categories (ten or twenty) plus additional sensitivity studies

MACCS Lineage

- Calculation of Reactor Accident Consequences (CRAC) Code (1975)
  - Developed for the Reactor Safety Study (WASH-1400)
- CRAC2 (1982)
  - Primarily used in 1982 siting study (NUREG/CR-2239)
- MELCOR Accident Consequence Code System (MACCS) (1990)
  - Primarily used in NUREG-1150
- MACCS2 (1998)
  - Developed to support DOE documented safety analyses of nuclear facilities
- WinMACCS/MACCS (2011)
  - Enhance user friendliness
  - Reduce likelihood of user errors
  - Enable routine examination of uncertainty

Phenomena Treated by MACCS

- Representation of source term
- Atmospheric transport and dispersion
  - Statistical sampling of archived weather data
- Wet and dry deposition
- Exposure pathways to humans
  - Inhalation
  - Cloudshine
  - Groundshine
  - Resuspension
  - Ingestion
- Emergency actions
  - Sheltering
  - Evacuation
  - KI ingestion
  - Relocation
- Long-term remedial actions
  - Decontamination
  - Temporary or permanent interdiction of property
  - Crop disposal
- Economic losses
  - Evacuation and relocation per diem costs
  - Long-term relocation cost
  - Decontamination costs
  - Loss of property use
  - Depreciation during interdiction
  - Property value for permanent interdiction



MACCS Code Modules

- ATMOS
  - Calculates transient air and ground concentrations
- EARLY
  - Treats emergency phase (up to 40 days, usually one week)
  - Models emergency response actions
  - Estimates doses from exposure pathways
  - Estimates health effects
- CHRONC
  - Treats intermediate phase (up to 30 years, usually one year)
  - Treats long-term phase (up to >300 years, usually 50 years)
  - Estimates long-term doses from exposure pathways
  - Estimates health effects
  - Calculates economic losses

Historical ATD Modeling

- Gaussian plume segment model
  - Plume buoyancy (Briggs model)
  - Building-wake effects (area source)
  - Gaussian dispersion with corrections for plume meander and surface roughness
  - Dry deposition
  - Wet deposition
- Originally chosen for simplicity and speed
  - Only requires single weather station data
  - Runs fast enough to perform hundreds or thousands of weather trials
  - Thought to be adequate for prospective analyses with statistical treatment of weather
- Current best practice is to create hour-long plume segments to match weather data

Improvements In MACCS 3.10 (5/15)

- Multi-source releases (requires MelMACCS 2.0.0 or newer)
- Extended durations
  - Alarm time (30 day)
  - Delay to release (30 day)
  - Emergency phase (40 day)
- Weather hours read from file increased from 120 to 1200
- User-definable dose projection periods for emergency and intermediate phases (previously duration of phase)
- Detailed output for people affected by countermeasures by phase
- User-definable return time for evacuees unaffected by release (previously duration of emergency phase)

Improvements in MACCS 3.11.2 (3/18)

Emergency response

- OALARM can be defined for each cohort.

Decontamination

- The limits on CDNFRM and CDFRM were increased to $1 M.
- The limits for decontamination and intermediate-phase durations are now 30 years.

Doses and health effects

- All organs listed in DCF file can be used to define health effects.
- The maximum number of early health effects increased to 10.
- The maximum number of cancer health effects increased to 40.

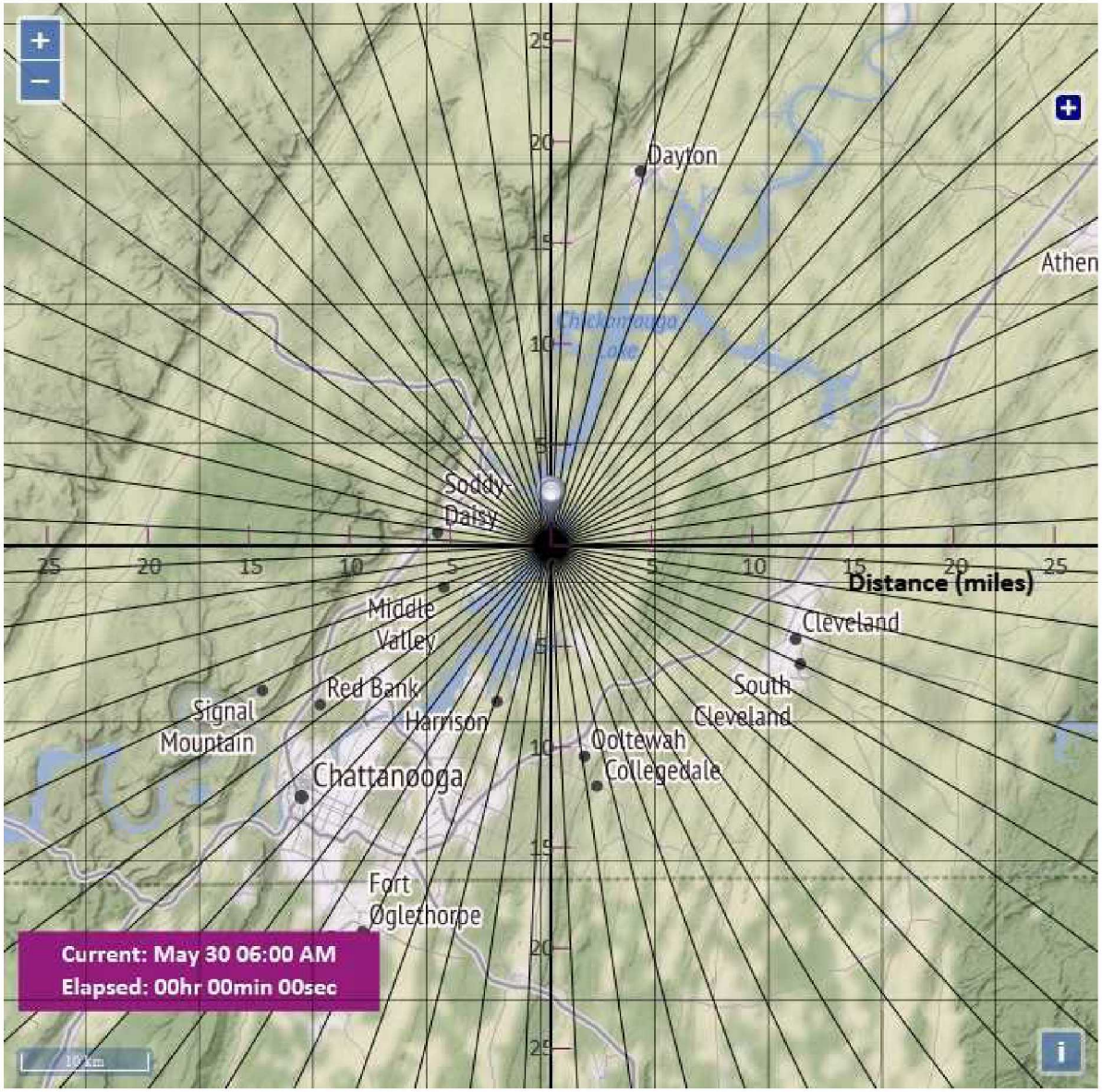
Usability

- MACCS now distributed as a 64-bit executable to eliminate memory errors.
- MACCS now allows scale factor for each radionuclide (analogous to CORSCA) to facilitate sensitivity analyses.

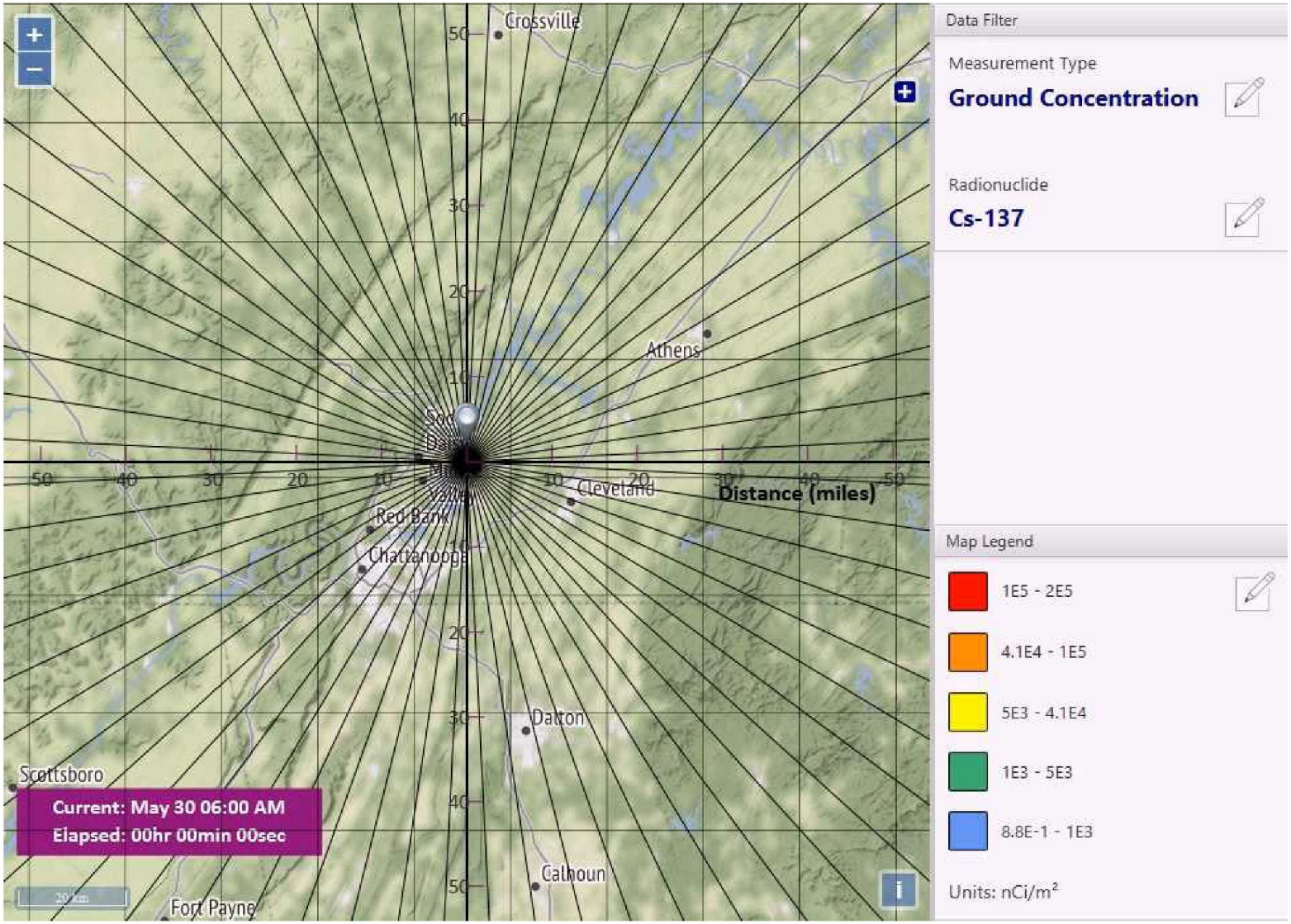
Under Development

- Alternative atmospheric transport model (HYSPLIT) to evaluate special issues
- Software tool for extracting single met tower data from archived, gridded files (e.g., from NOAA)
- Evaluation of near-field modeling options
- Alternative economic model to evaluate GDP losses
  - Based on input-output economic model
  - Uses modified REAcct code developed by NISAC for DHS called RDEIM
- Animation capability
- Draft input parameter guidance document

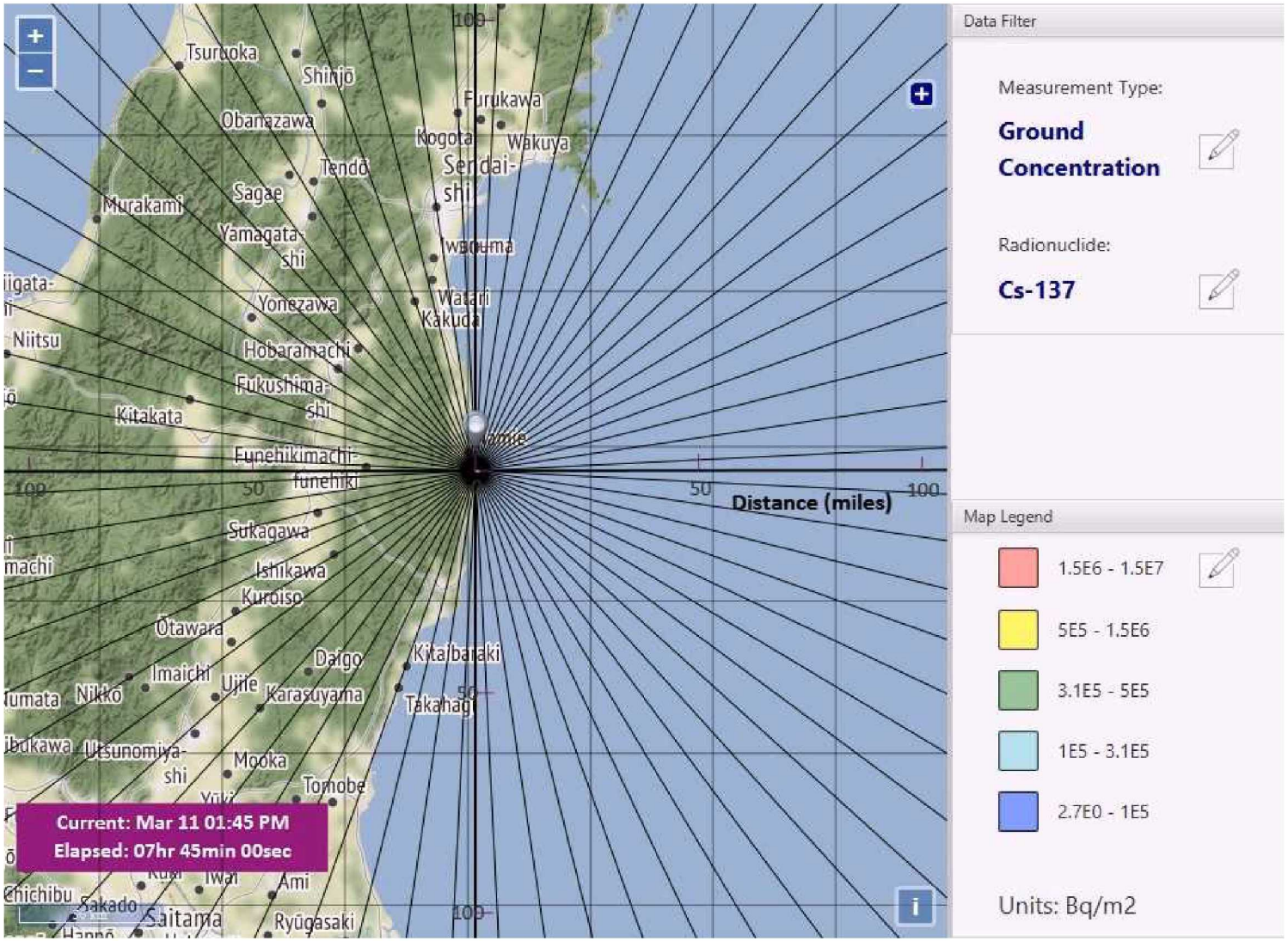
Animation of Plume Segments



Animation of Ground Deposition (Gaussian)



Animation of Ground Deposition (HYSPLIT)



Current Applications at NRC and Sandia

- Fukushima benchmarking
- Peer review of ATD model benchmarking at five US sites
- Sequoyah uncertainty analysis (SOARCA)
- Surry uncertainty analysis (SOARCA)
- NRC Level-3 PRA
- Development of input parameter guidance

Summary

- MACCS is being developed to perform prospective consequence analysis of potential atmospheric releases of nuclear materials
- Current version treats
  - Atmospheric transport and dispersion
  - Dose pathways to humans
  - A wide variety of consequences
  - Very general multi-source releases
- Ongoing development includes
  - Highly detailed atmospheric transport model option
  - GDP-based economic loss option
  - Animation tool
  - Evaluation of options for near-field atmospheric transport
- NRC and Sandia are currently performing a wide variety of MACCS applications

List of Acronyms

ATD	Atmospheric Transport and Dispersion
CRAC	Calculation of Reactor Accident Consequences
DCF	Dose Conversion Factor
DHS	Department of Homeland Security
GDP	Gross Domestic Product
HYSPLIT	Hybrid Single Particle Lagrangian Integrated Trajectory
MACCS	MELCOR Accident Consequence Code System
NISAC	National Infrastructure Simulation and Analysis Center
NOAA	National Oceanic and Atmospheric Administration
NRC	Nuclear Regulatory Commission
PRA	Probabilistic Risk Assessment
RDEIM	Regional Disruption Economic Impact Model
REAcct	Regional Economic Accounting tool
SNL	Sandia National Laboratories
SOARCA	State-of-the-Art Reactor Consequence Analyses