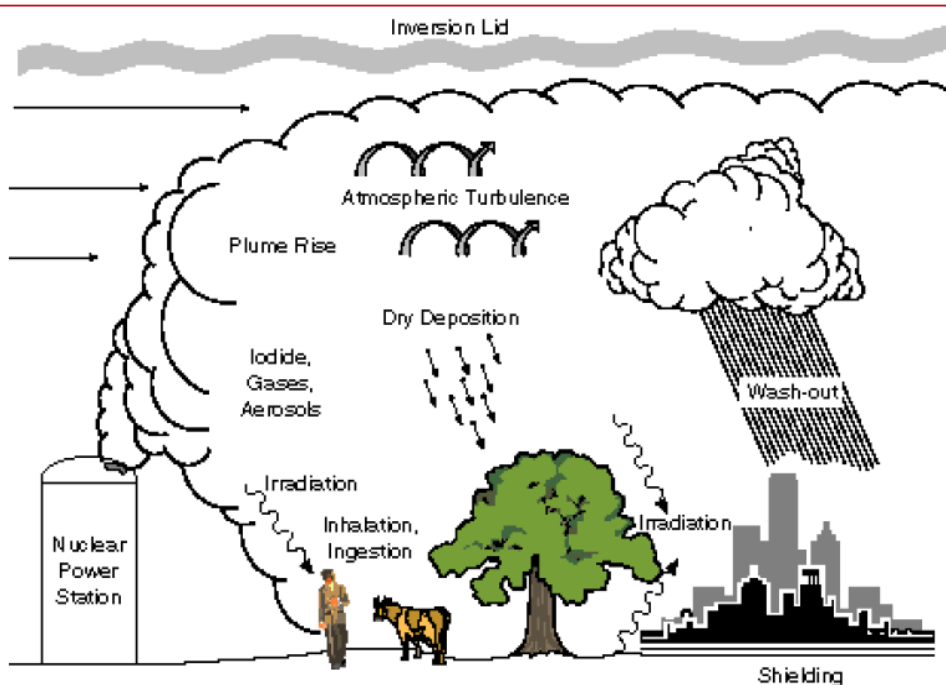


# Overview of MACCS Code Development and Applications



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Presented at the 2018 International MACCS Users Group Meeting  
Bethesda, MD, USA, June 11-12, 2018

# Outline

- MELCOR Accident Consequence Code System (MACCS) overview
- Improvements in the most recent versions
- New models under development
- Applications
- Summary

# History of MACCS

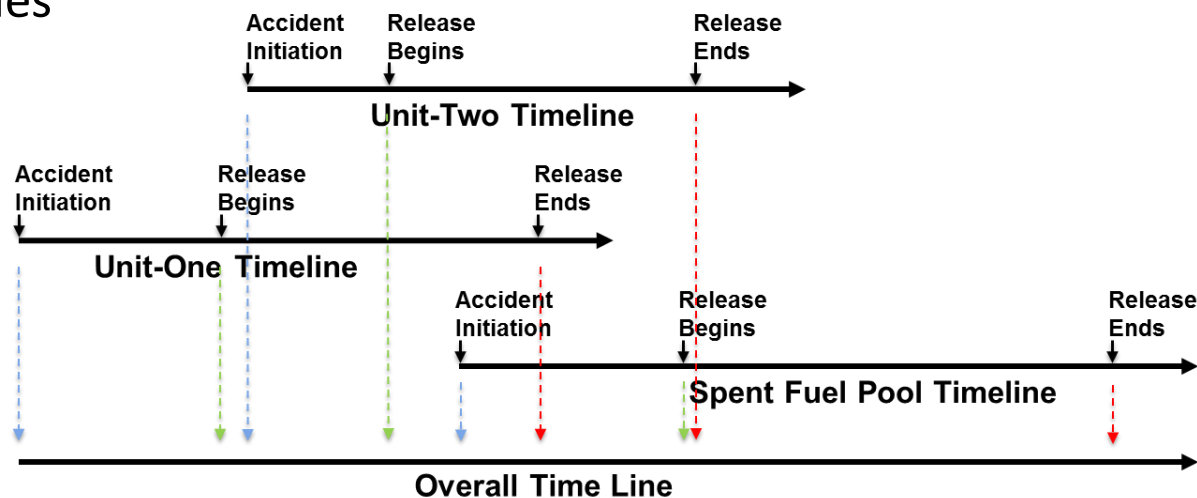
- Developed as a PRA tool to assess risk and consequences from a hypothetical release of radioactive material into the atmosphere
  - Performs statistical evaluation of weather variability
  - Accounts for emergency and long-term responses
  - Assesses a wide variety of consequence metrics
- Developed and maintained by Sandia National Laboratories for the U.S. Nuclear Regulatory Commission
- Evolved from codes used in the 1970s through the 1990s
  - CRAC (1975)
  - CRAC2 (1982)
  - MACCS (1990)
  - MACCS2 (1998)
  - WinMACCS/MACCS (2011 through 2018)

- Models treat
  - Atmospheric transport and deposition
  - Statistical effect of variability in weather
  - Dose pathways for cloudshine, groundshine, inhalation, ingestion, and deposition onto skin
  - Protective actions during emergency, intermediate, and long-term phases
- Calculates offsite consequences
  - Doses
  - Health effects
  - Economic costs
  - Land contamination

## 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)

- Allows releases from multiple units with independent
  - Accident initiation times
  - Release time line
  - Isotopic inventories
- Allows releases from a spent fuel pool with multiple rings (cooling times) with independent
  - Release time line
  - Isotopic inventories



# Fixes In MACCS 3.10.1.2 (9/16)

- Evaluation of travel time through a grid element with network evacuation was corrected
- Centerline dose error introduced in MACCS 3.10.0 was corrected
- A discrepancy between the input and output values of day and hour for a weather trial was corrected
- Two bugs in the implementation of the keyhole evacuation model were corrected

# 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**

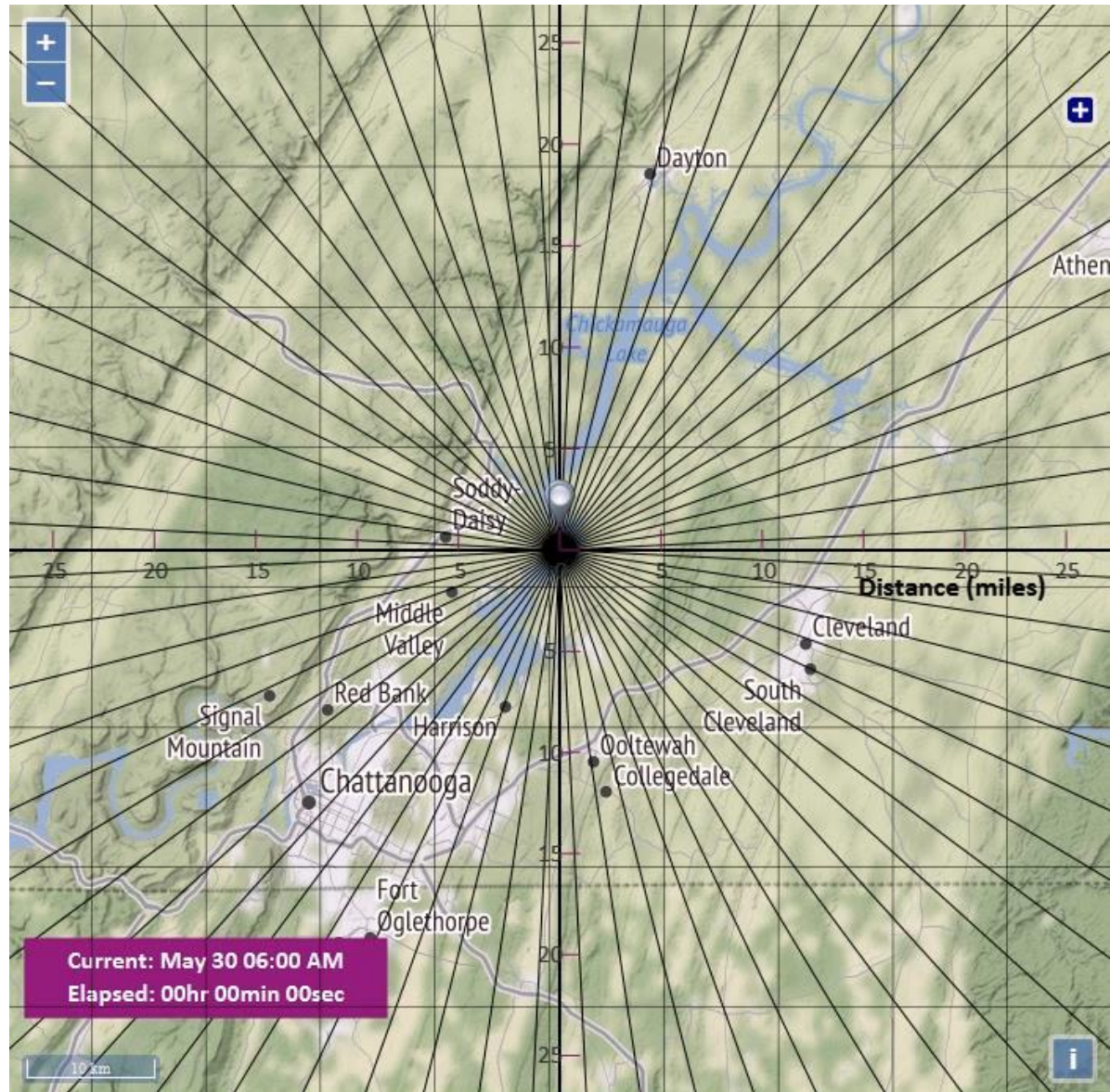
- MACCS now distributed as a 64-bit executable to eliminate memory errors.
- MACCS now allows scale factor for each radionuclide (analogous to CORSCA) to facilitate sensitivity analyses.



# New Models Under Development

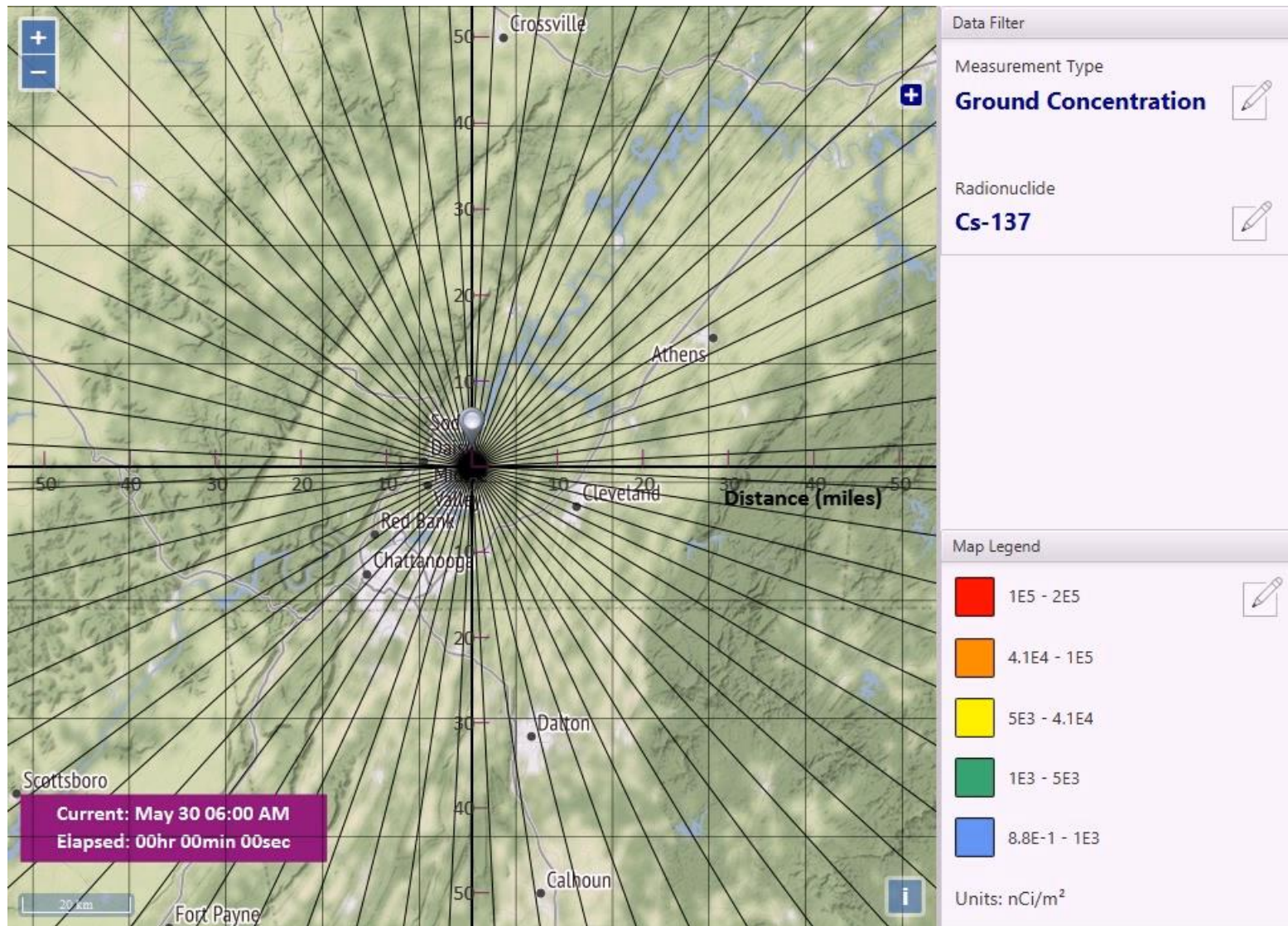
- Software tool for extracting single met tower data from archived, gridded files (e.g., from NOAA)
  - More details in afternoon
- Alternative atmospheric transport model (HYSPLIT) to evaluate special issues
  - More details on Tuesday afternoon
- Alternative economic model to evaluate GDP losses
  - Based on input-output economic model
  - Uses modified REAcct code developed by NISAC for DHS
  - Presented at 2017 IMUG Meeting
- Animation capability

# Animation of Plume Segments

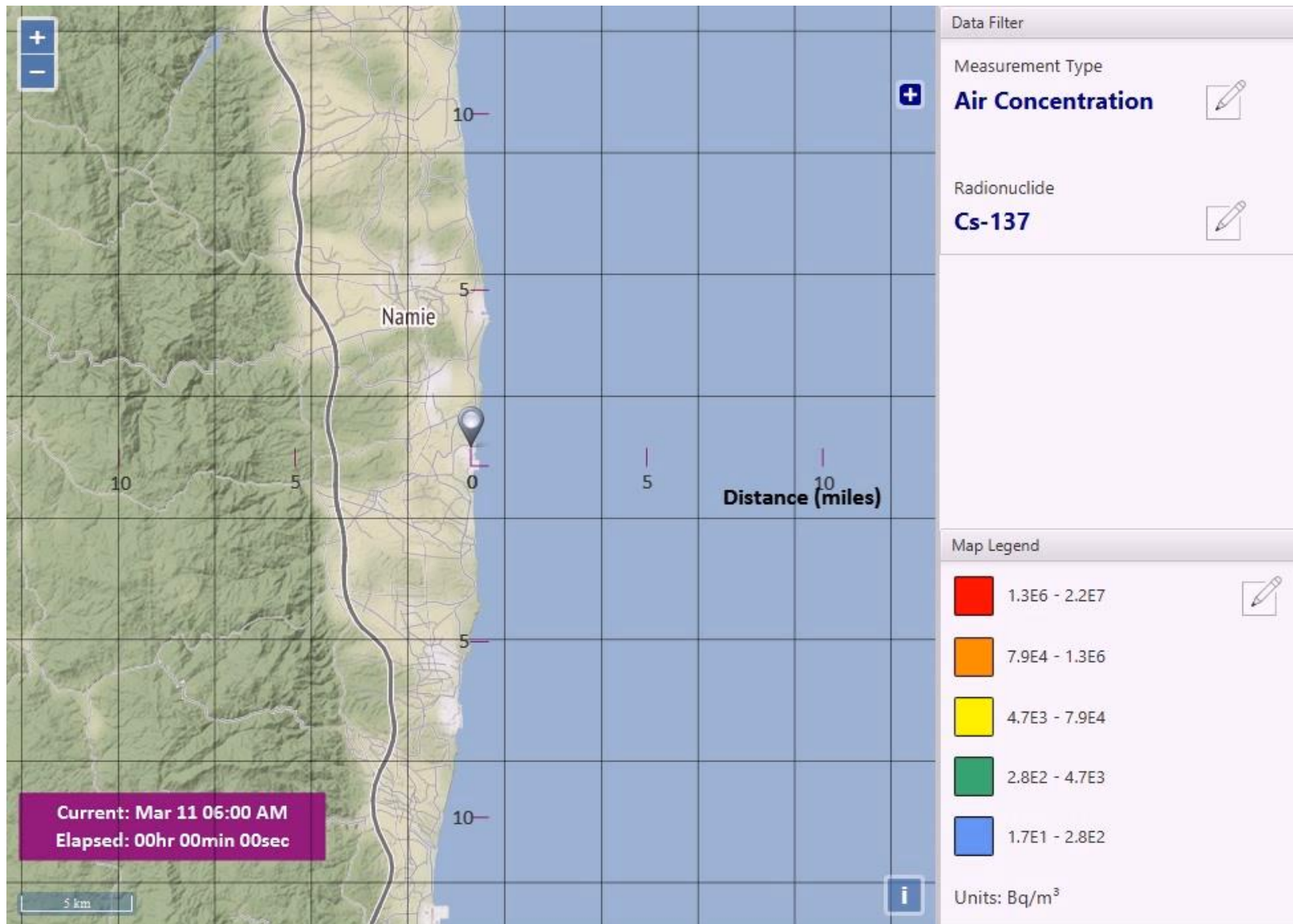




# Animation of Ground Deposition

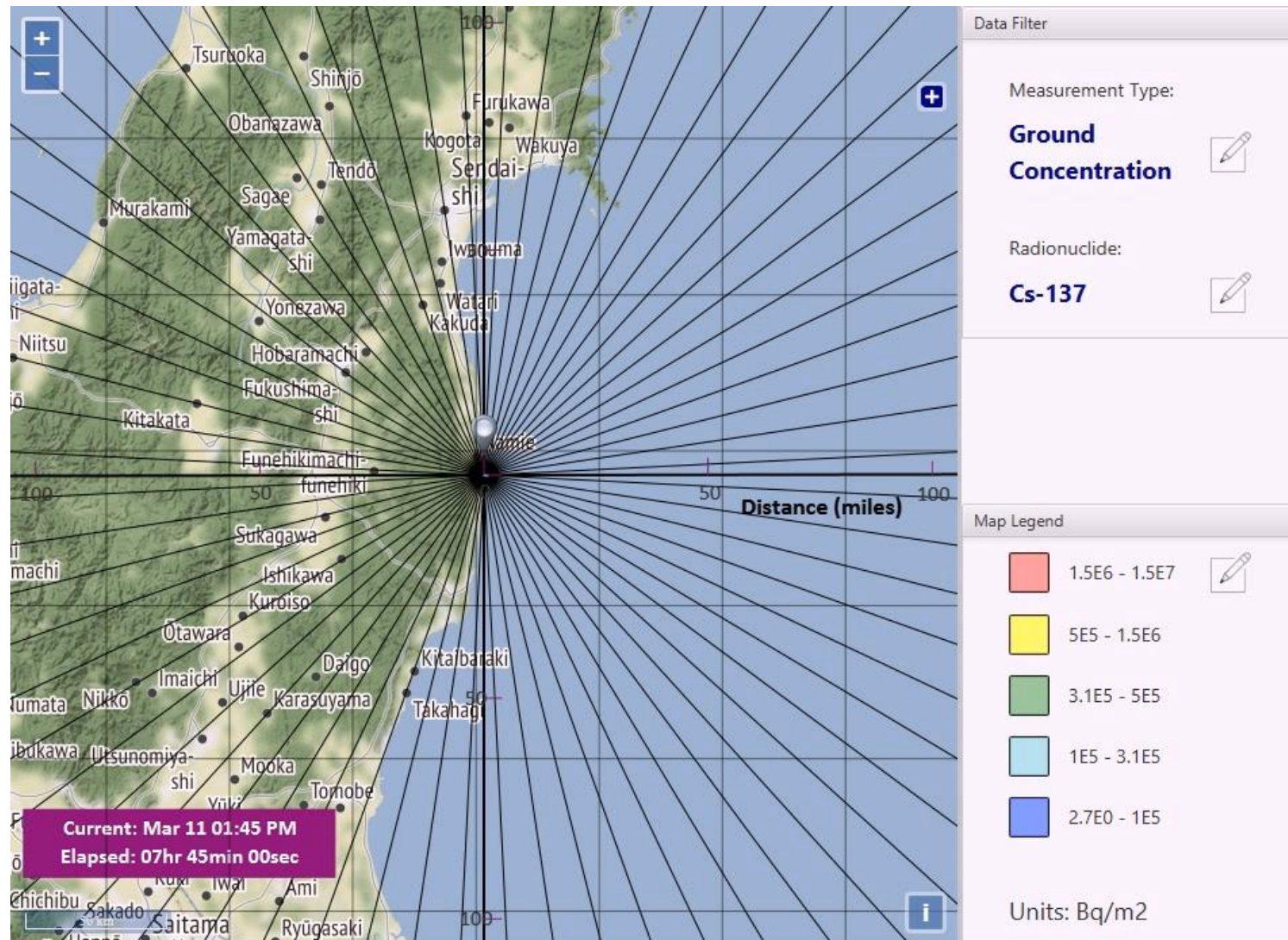


# Air Concentration Isopleths

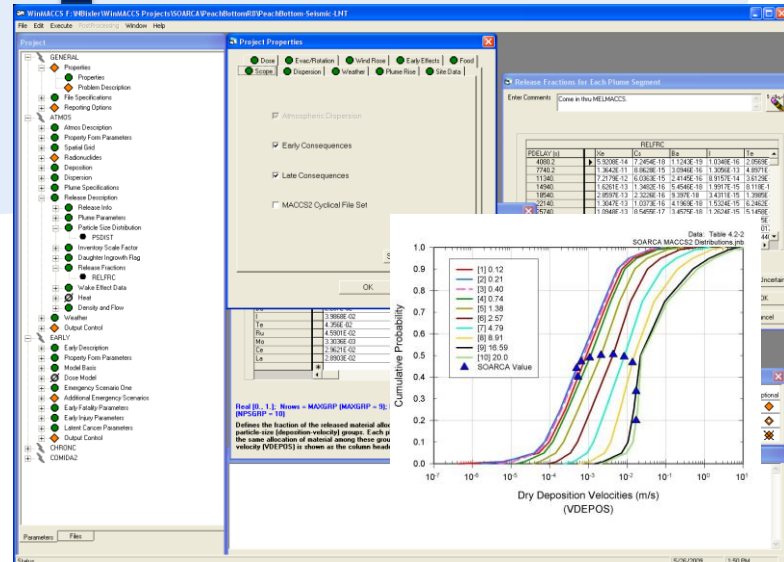
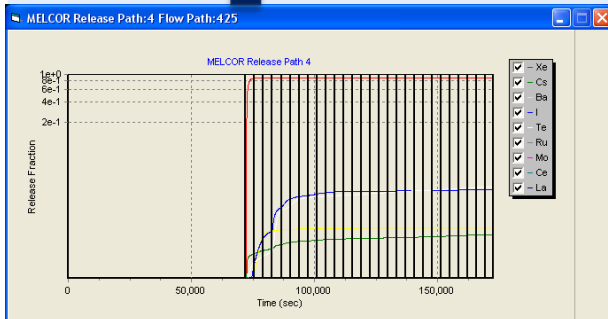
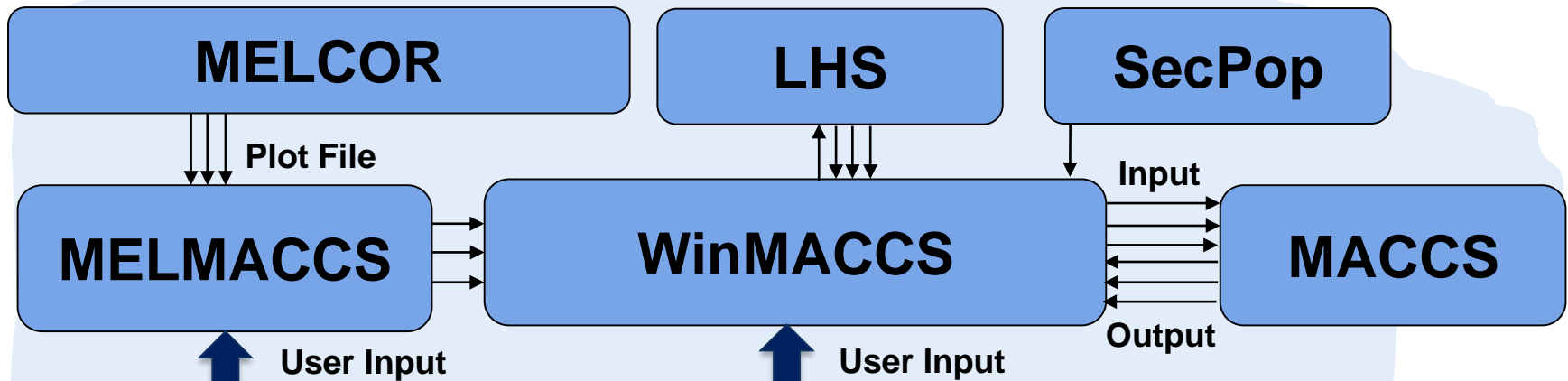




# Ground Concentration Isopleths



# Typical WinMACCS Calculation Framework



# Current Applications

- Fukushima benchmarking
  - More details this afternoon
- ATD model benchmarking
  - More details Tuesday afternoon
- Sequoyah uncertainty analysis (SOARCA)
  - Presentations at upcoming PSAM 14 Conference (UCLA)
  - Draft report on NRC web site
  - Final version of report expected in 2018
- Surry uncertainty analysis
  - Report expected in 2018
- NRC Level-3 PRA

# Summary

- MACCS 3.11.2
  - Emergency response
  - Timing and cost of decontamination
  - Doses and health effects
  - Usability
- Ongoing code developments
  - Extraction of MACCS weather data from archived data
  - Integration of HYSPLIT with MACCS as an alternative ATD model
  - Option for economic modeling based on GDP losses
  - Animation of plume segments, air concentrations, and ground depositions
- A variety of MACCS applications are ongoing at the NRC and Sandia



# 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
IMUG	International MACCS Users' Group
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
REAcct	Regional Economic Accounting tool
SecPop	Sector Population, Land Fraction, and Economic Estimation Program
SOARCA	State-of-the-Art Reactor Consequence Analyses
UCLA	University of California at Los Angeles