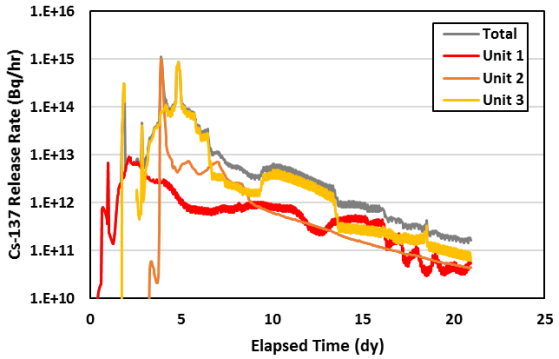
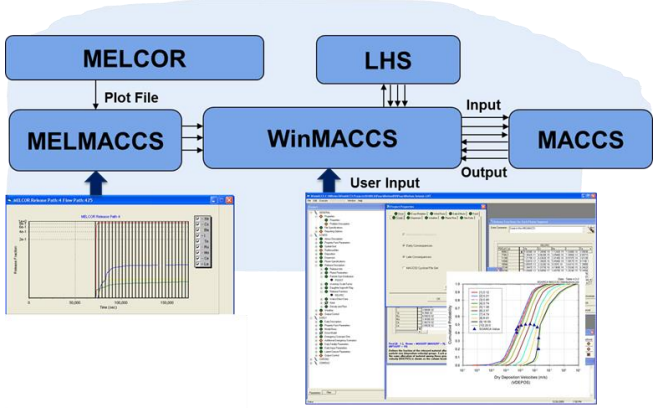
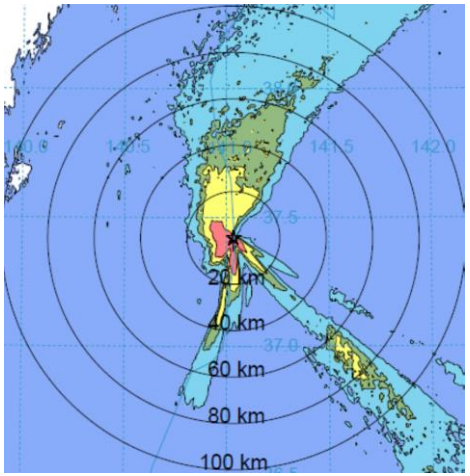
U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

Exceptional service in the national interest

Sandia National Laboratories







Final Atmospheric Transport and Land Contamination Results for Fukushima Daiichi Units 1, 2, & 3

Nathan E. Bixler and Daniel J. Clayton

Sandia National Laboratories

Presented at the IMUG Meeting

Bethesda, MD, USA, June 11-12, 2018

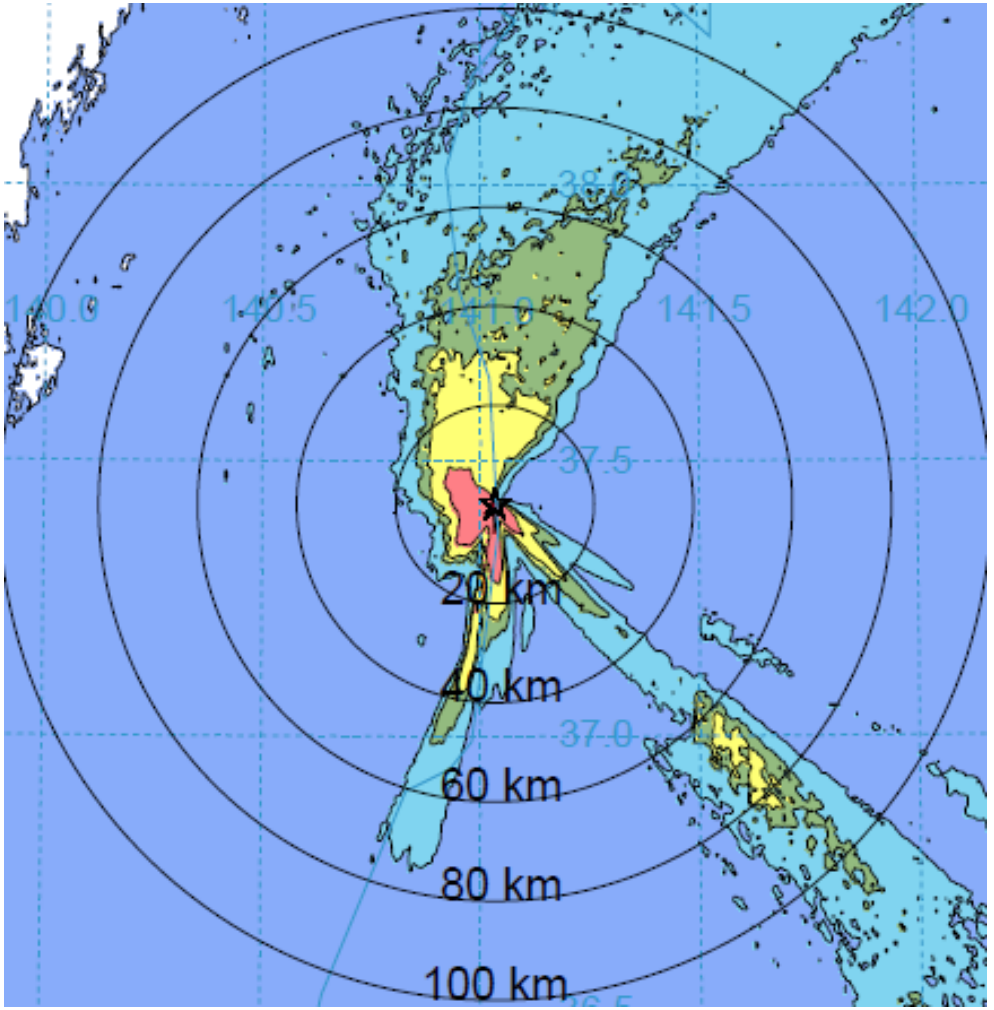
U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

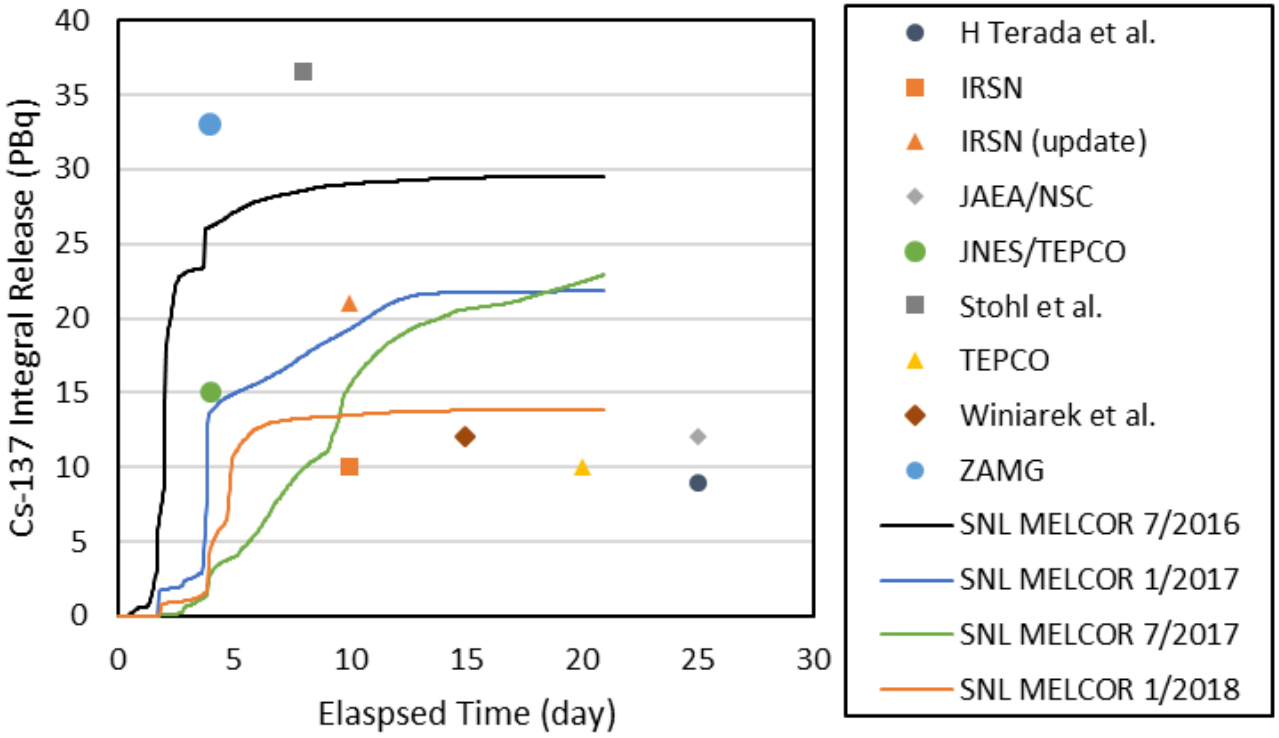
Sandia National Laboratories is a multi-mission laboratory managed and operated by National Technology and Engineering Solutions of Sandia, LLC., a wholly owned subsidiary of Honeywell International, Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA-0003525. SAND2018-6110 PE

Overview

- SNL MELCOR source term
- Meteorological data
- Deposition predictions
- Source terms and HYSPLIT results for BSAF participants
- Summary



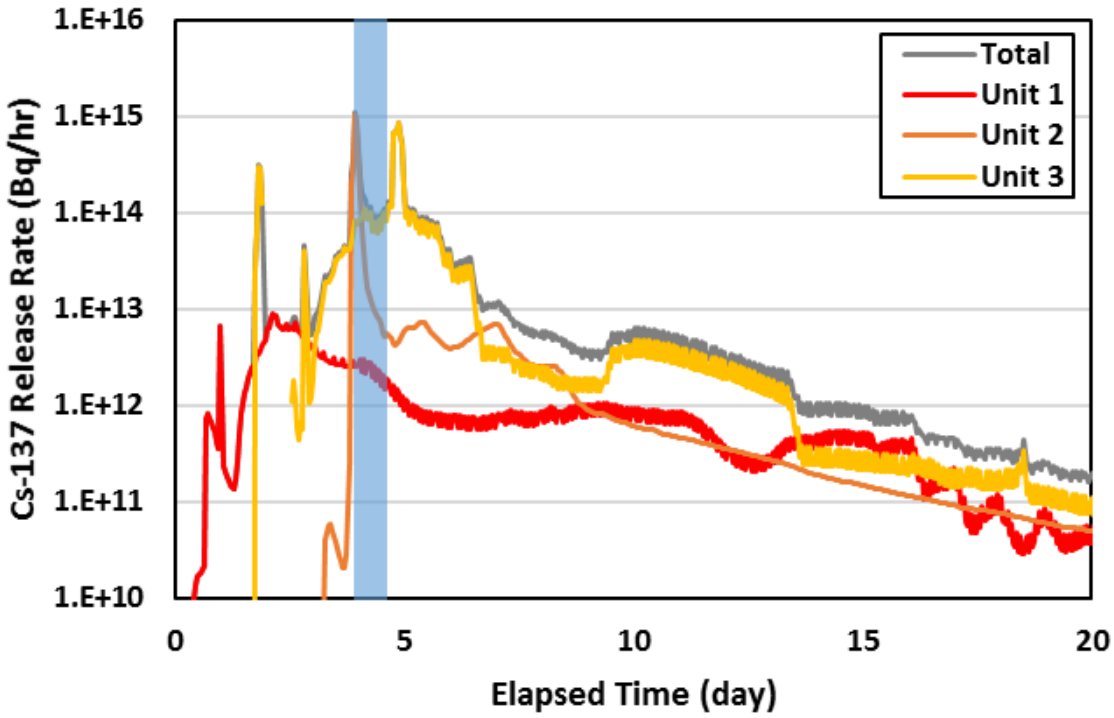
Integral Release Estimates



- Current MELCOR total Cs-137 release for all three units
  - Total release is about 14 PBq
  - Released activity aligns with other estimates
  - About 4% is from Unit 1, 26% from Unit 2, and 70% from Unit 3

Observations on Current Source Term

- Release rate is 10^{13} to 10^{14} Bq/hr over most of the transient
- Larger release spikes (> 10^{14} Bq/hr) occur at
  - 44-46 hours (U3)
  - 92-102 hours (U2)
  - 114-119 hours (U3)
- Second spike starts at the beginning of transition to NW wind



Objectives of Atmospheric Transport Analysis

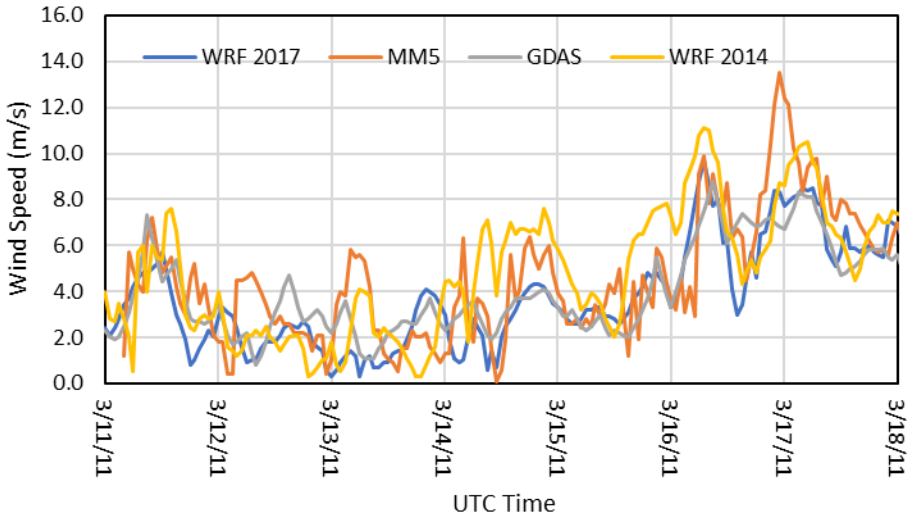
- Evaluate viability of SNL MELCOR source terms by reasonably replicating Cs-137 ground deposition patterns
- Provide guidance in release timing and magnitude for source term analysts
- Benchmark models against real data
  - HYSPLIT particle tracking model
    - As a stand-alone model
    - Integrated with MACCS

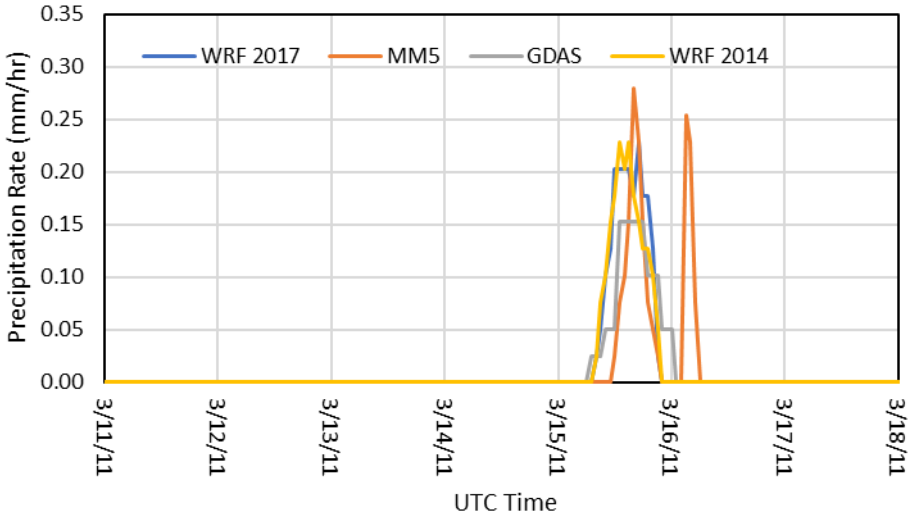
Atmospheric Transport Analysis

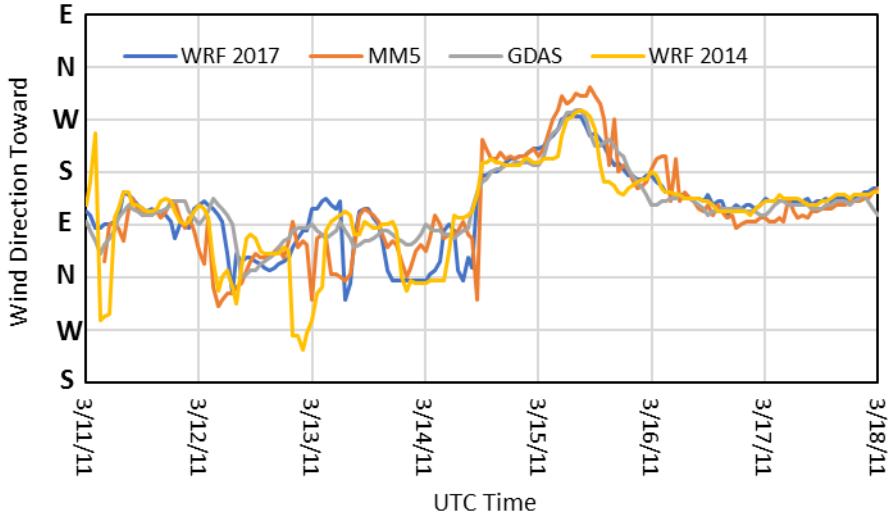
- Weather data from four sources
  - WRF by NOAA, generated 2017
    - 4-km spatial, 5 min temporal discretizations
    - Nudged with observations
  - GDAS from NOAA
    - 0.5 degrees spatial, 3 hour temporal discretizations
  - MM5 from JAEA
    - 1-km spatial, 1 hour temporal discretizations
  - WRF by NOAA, generated 2014
    - 4-km spatial, 20 min temporal discretizations
- HYSPLIT atmospheric transport analysis
  - Releases use correct location for each unit
  - Account for plume buoyancy

Meteorological Data for First 7 Days

- Show similar trends
- Variations in details

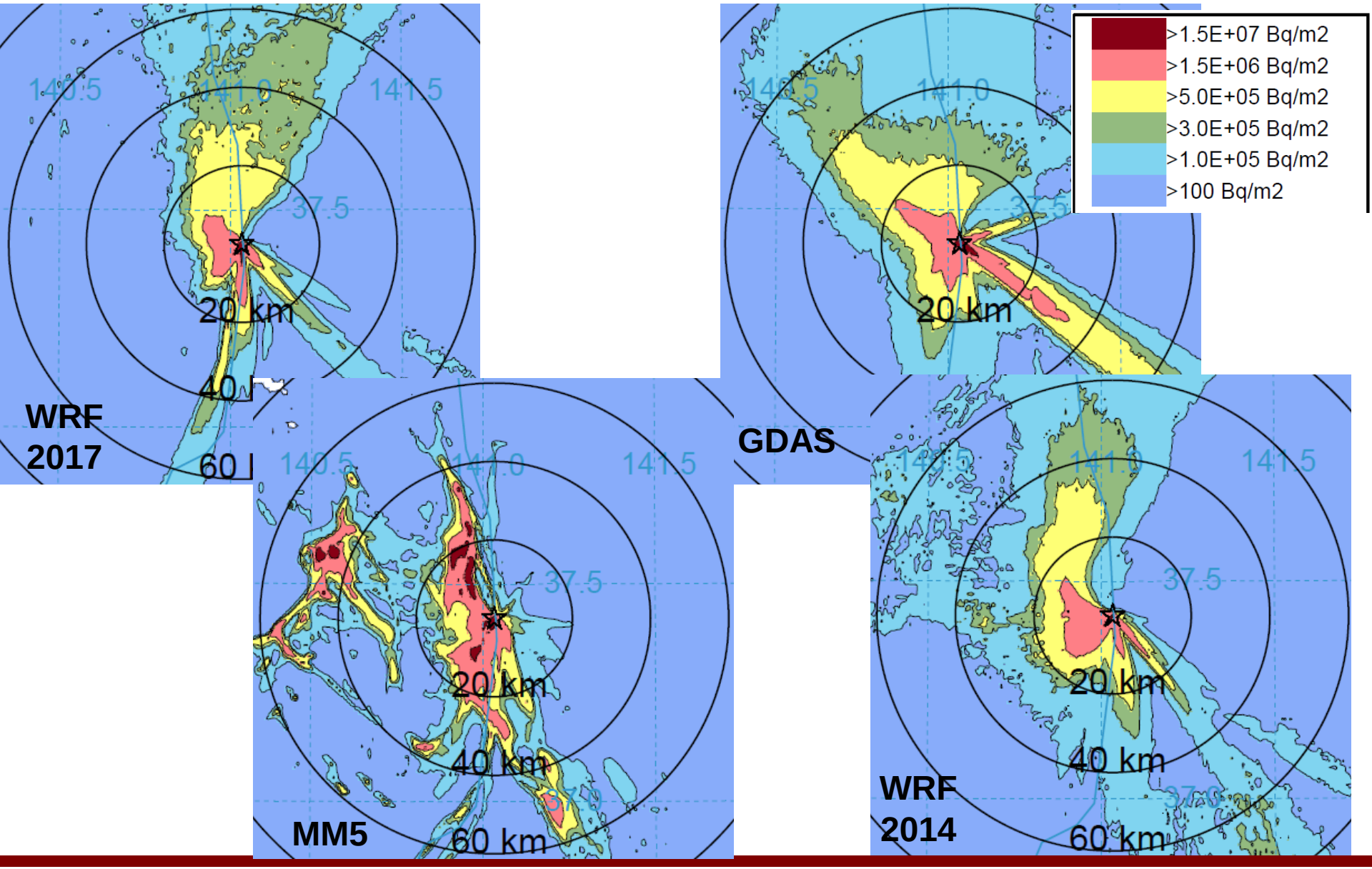






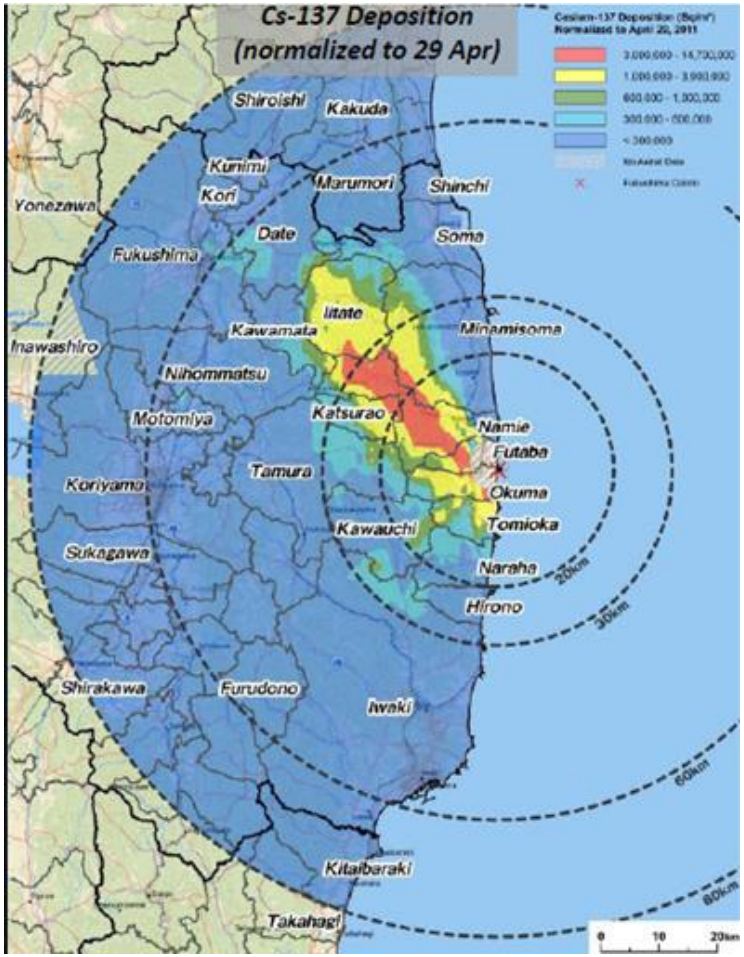
Deposition Comparison

SNL MELCOR 1/2018

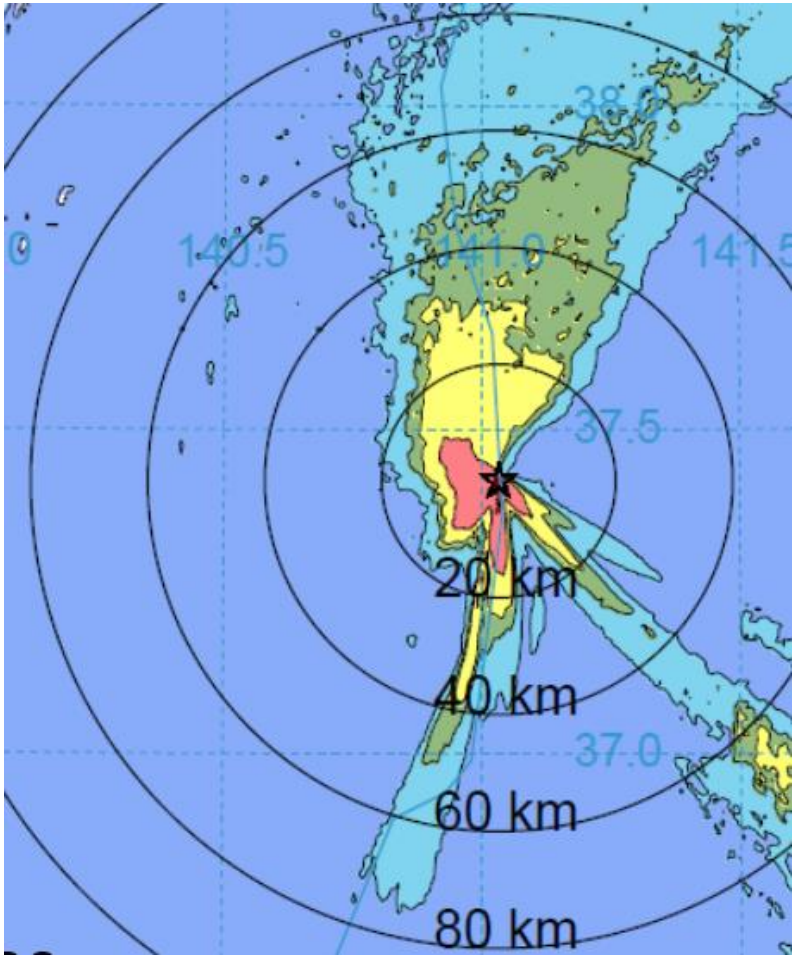


Comparison of Observations with Current Results

Observed Concentrations

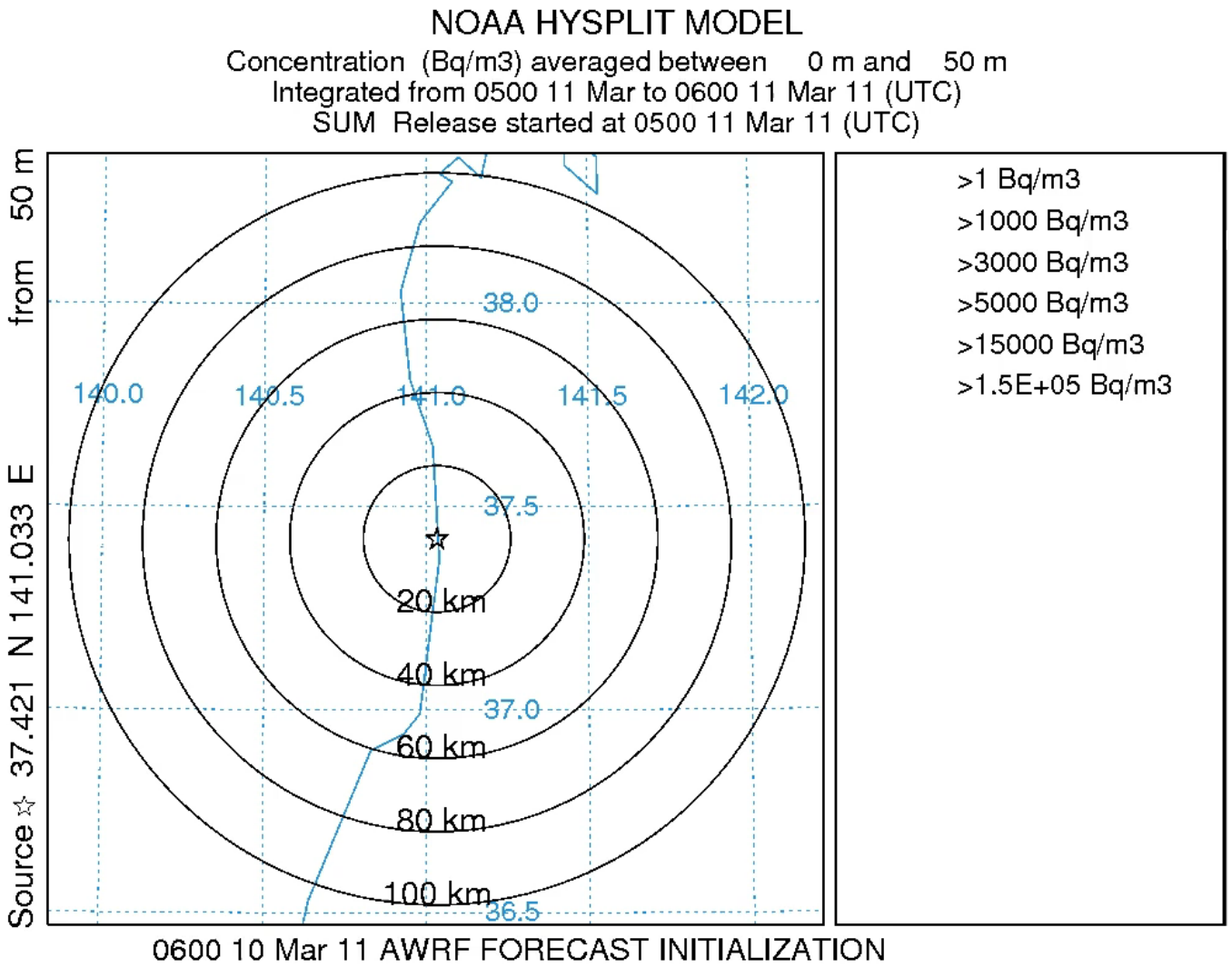


WRF 2017 SNL MELCOR 1/2018



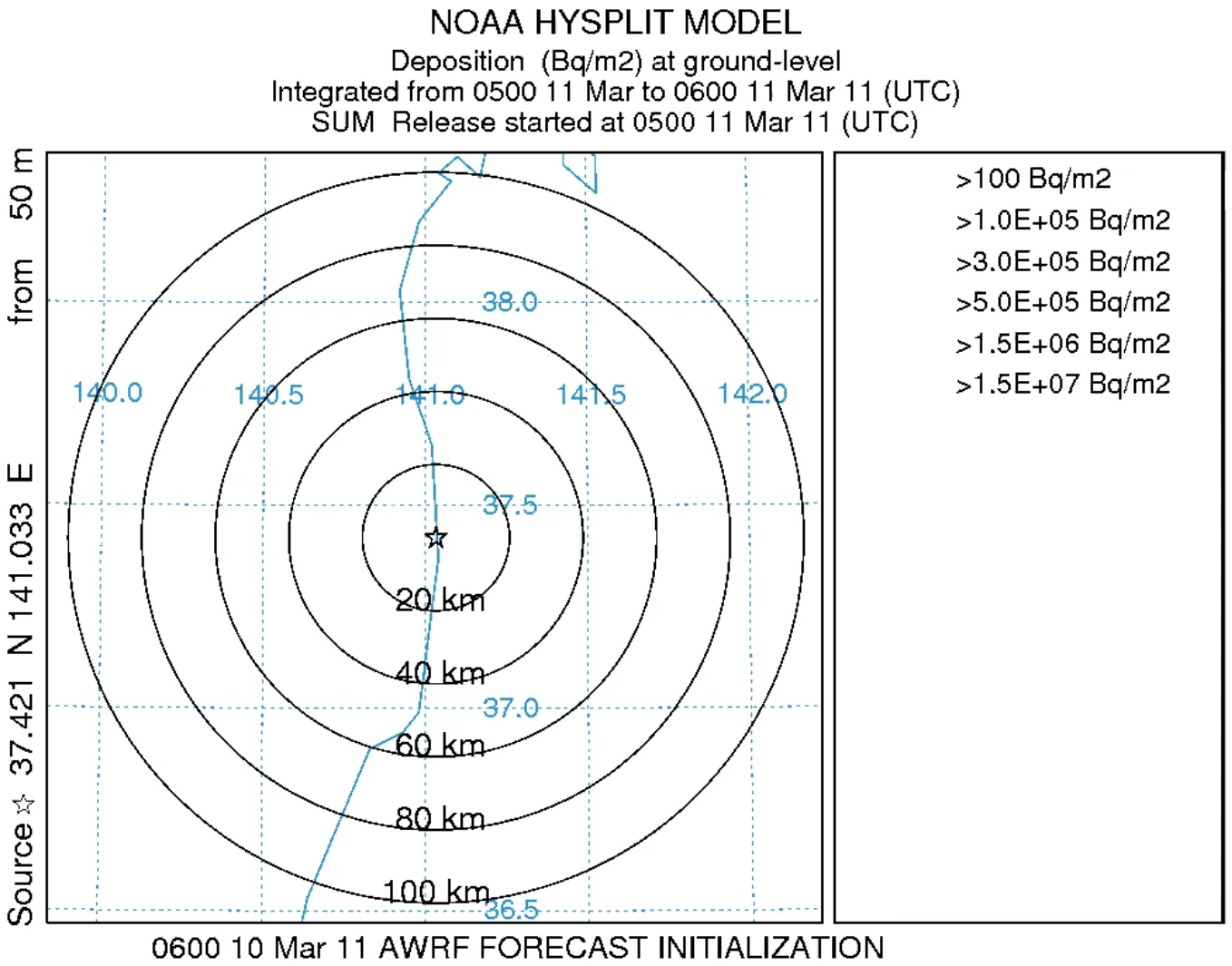
Predicted Air Concentrations

WRF 2017 SNL MELCOR 1/2018 Source Term



Predicted Ground Deposition

WRF 2017 SNL MELCOR 1/2018 Source Term

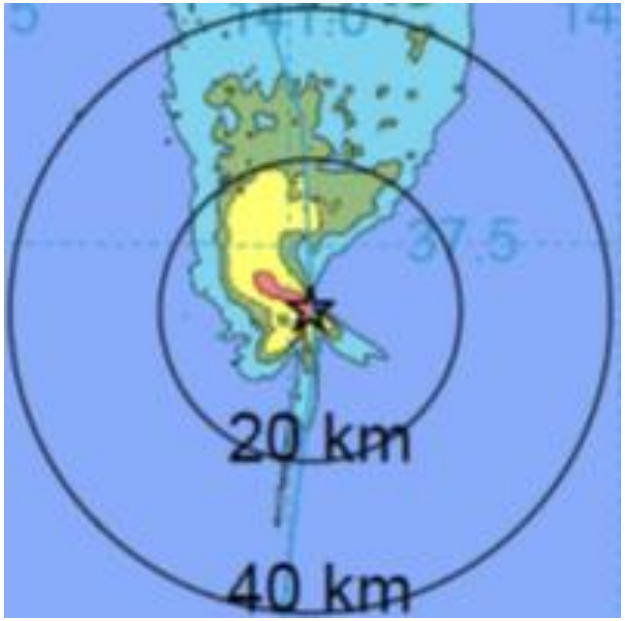


Contributions to Deposition Pattern from Individual Units

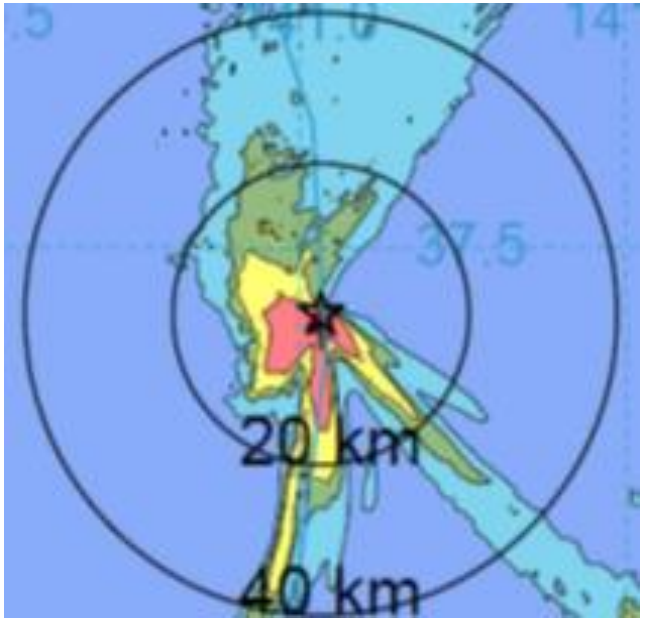
- Figures show final deposition patterns created by each unit
- Unit 2 creates initial NW deposition pattern on 3/15, similar to the observations
- Unit 3 dominates final deposition pattern

Unit 1

Unit 2



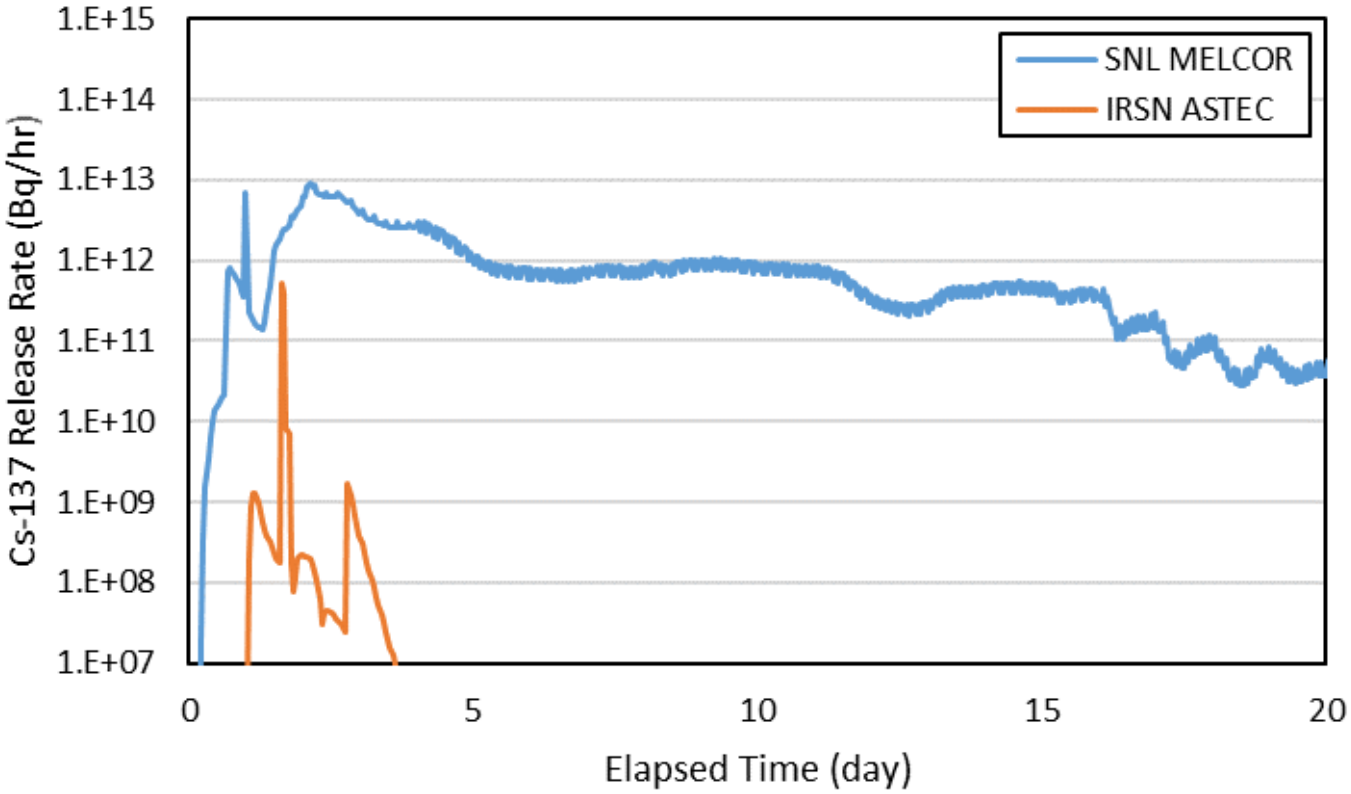
Unit 3



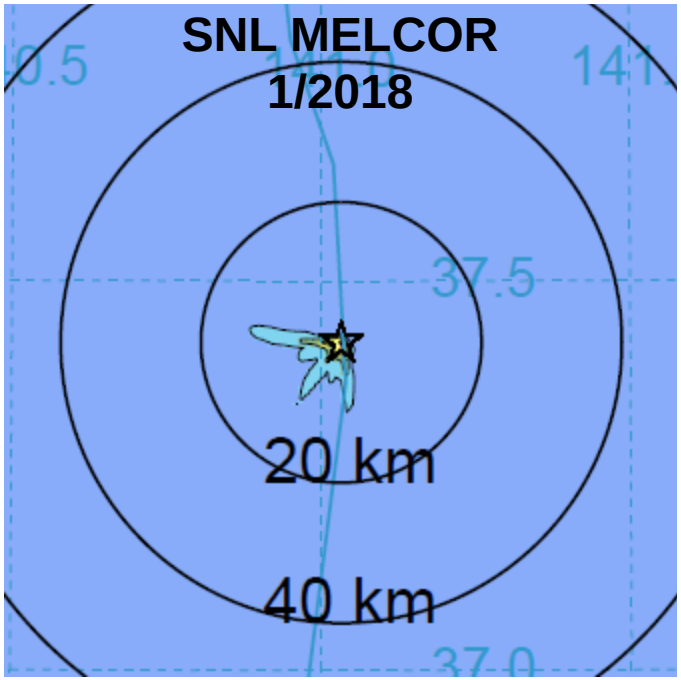
BSAF Source Terms

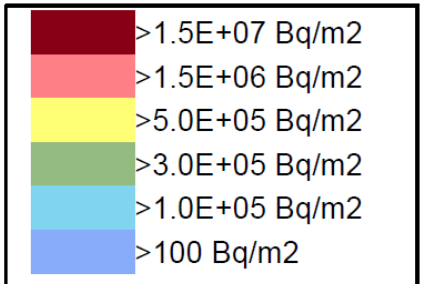
- Received source terms from five BSAF participants
  - SNL MELCOR – Unit 1, 2 & 3
  - IRSN ASTEC – Unit 1, 2 & 3
  - CNL MELCOR – Unit 2
  - CRIEPI MAAP – Unit 2
  - PSI MELCOR – Unit 3
- Computed final deposition patterns from each source term
  - WRF 2017 meteorological data
- Comparison for each unit and total
  - Source term
  - Deposition pattern

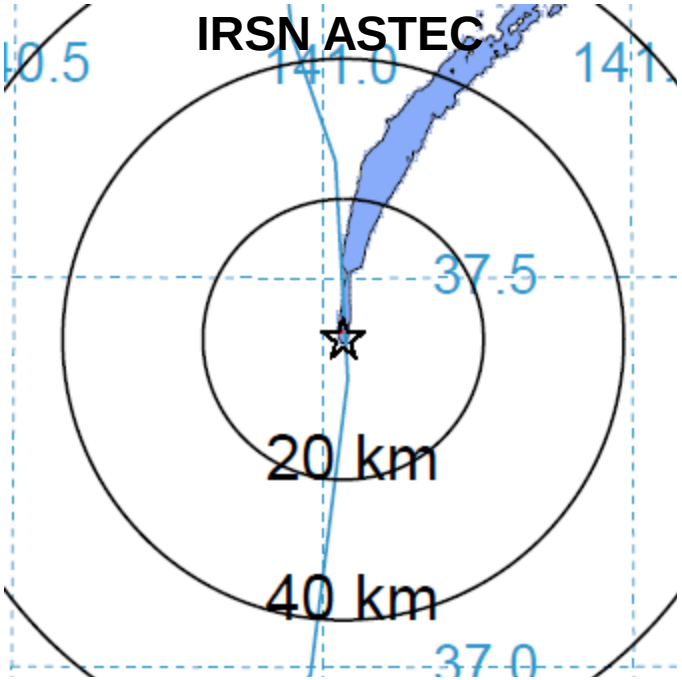
Unit 1 Source Term Comparison



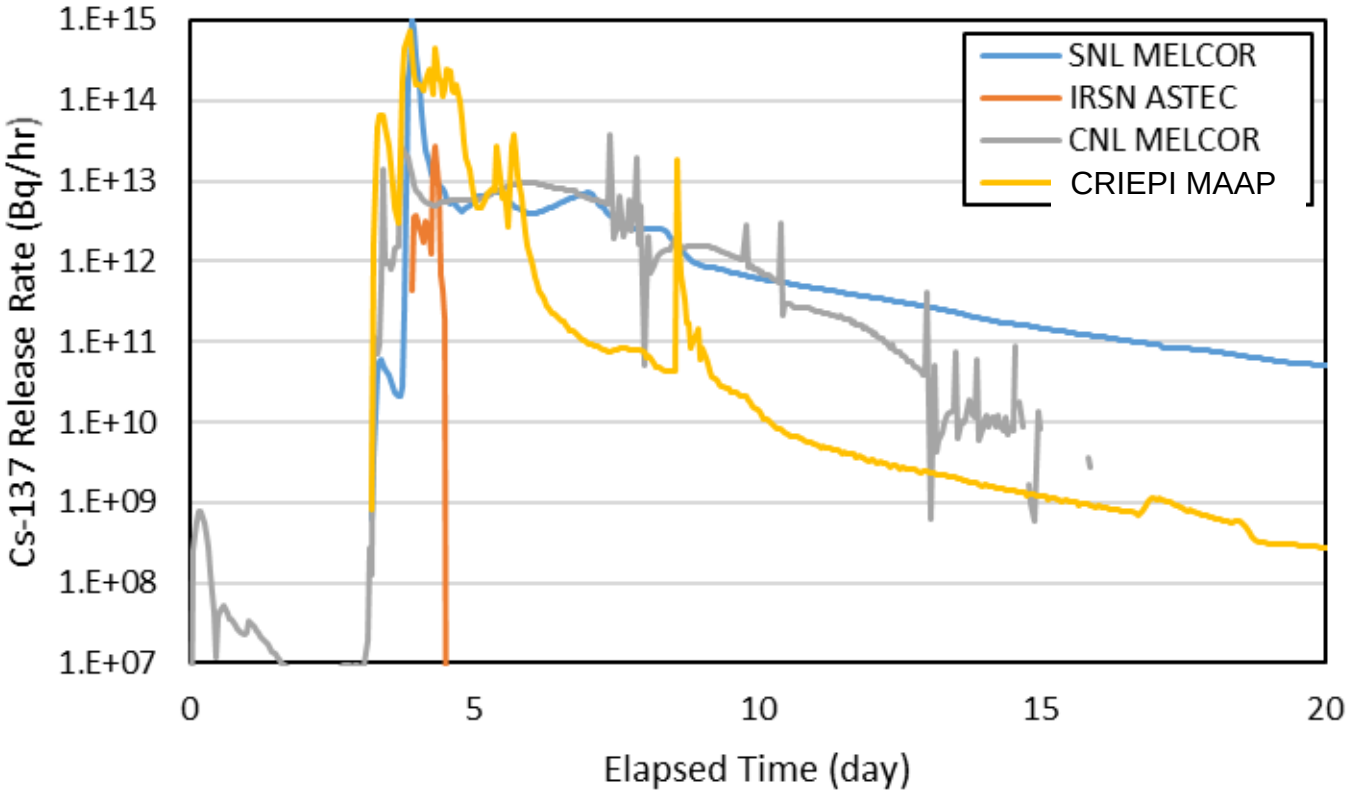
Unit 1 Deposition Comparison



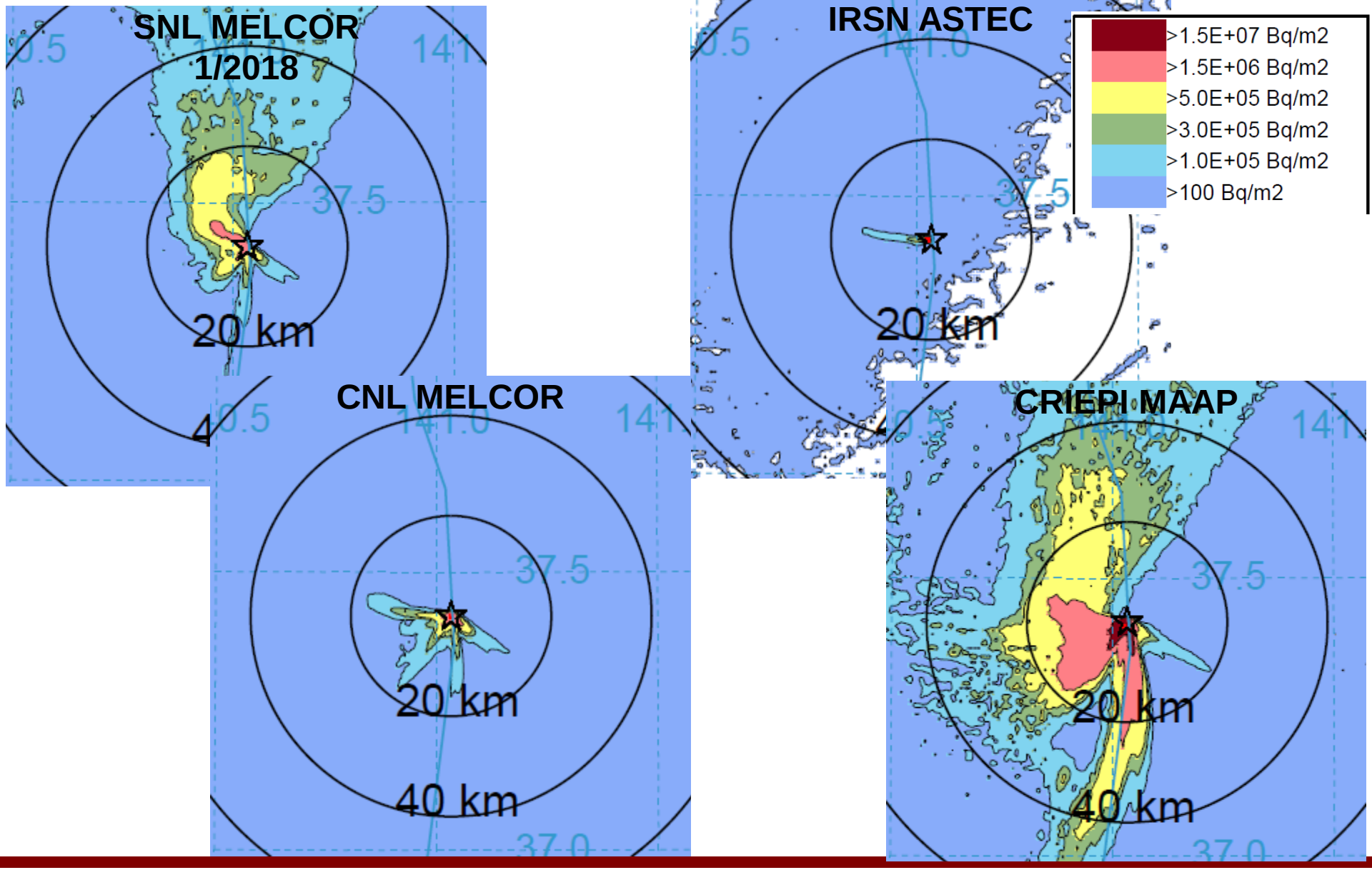




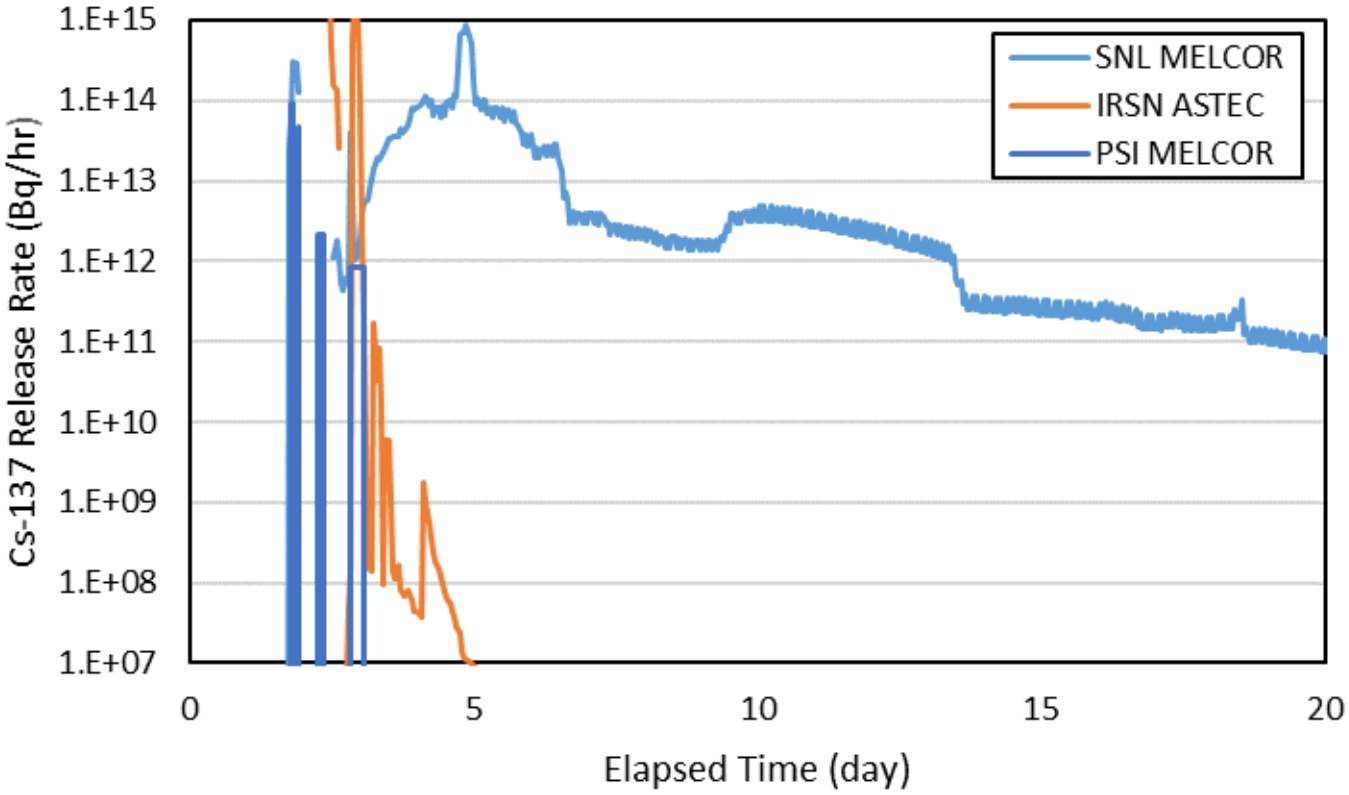
Unit 2 Source Term Comparison



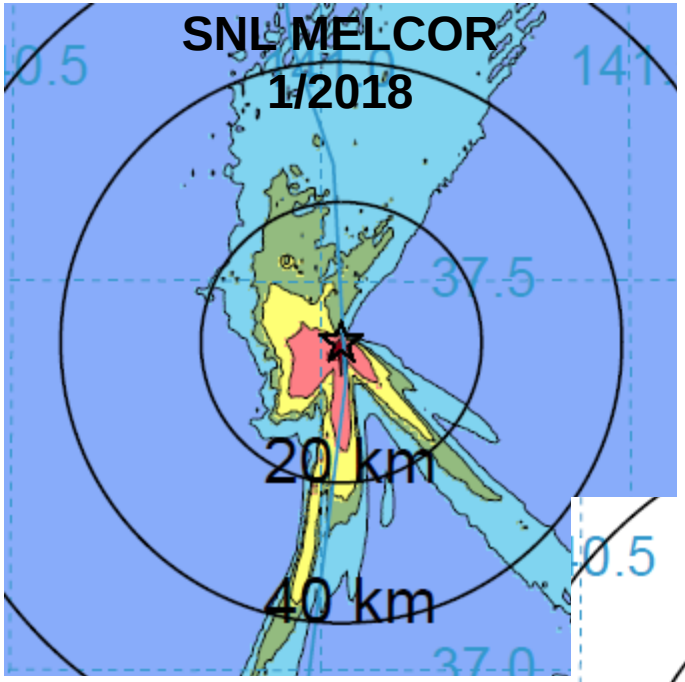
Unit 2 Deposition Comparison

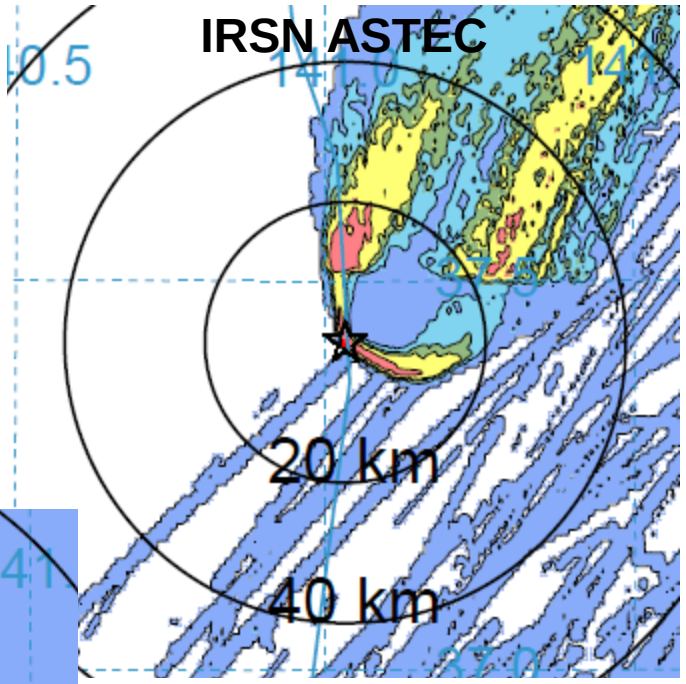


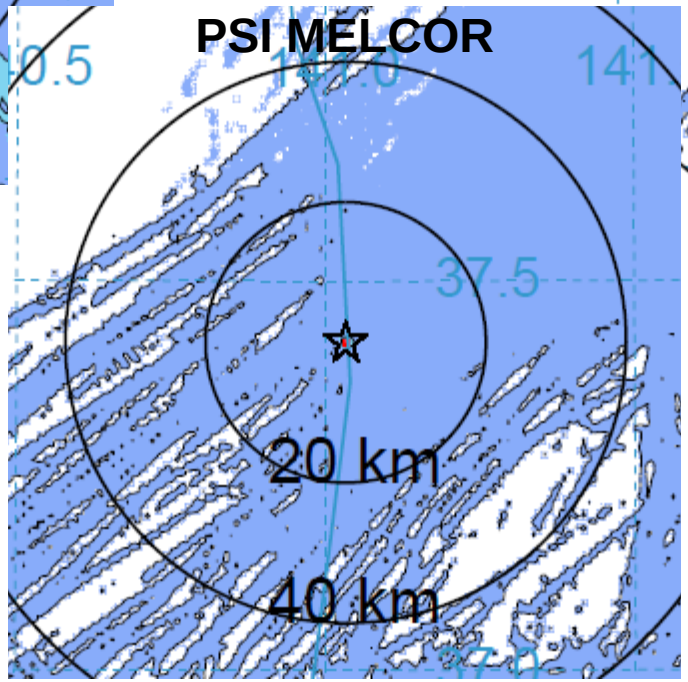
Unit 3 Source Term Comparison

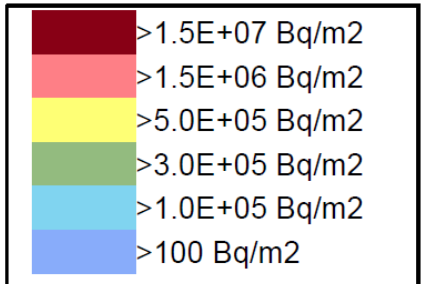


Unit 3 Deposition Comparison

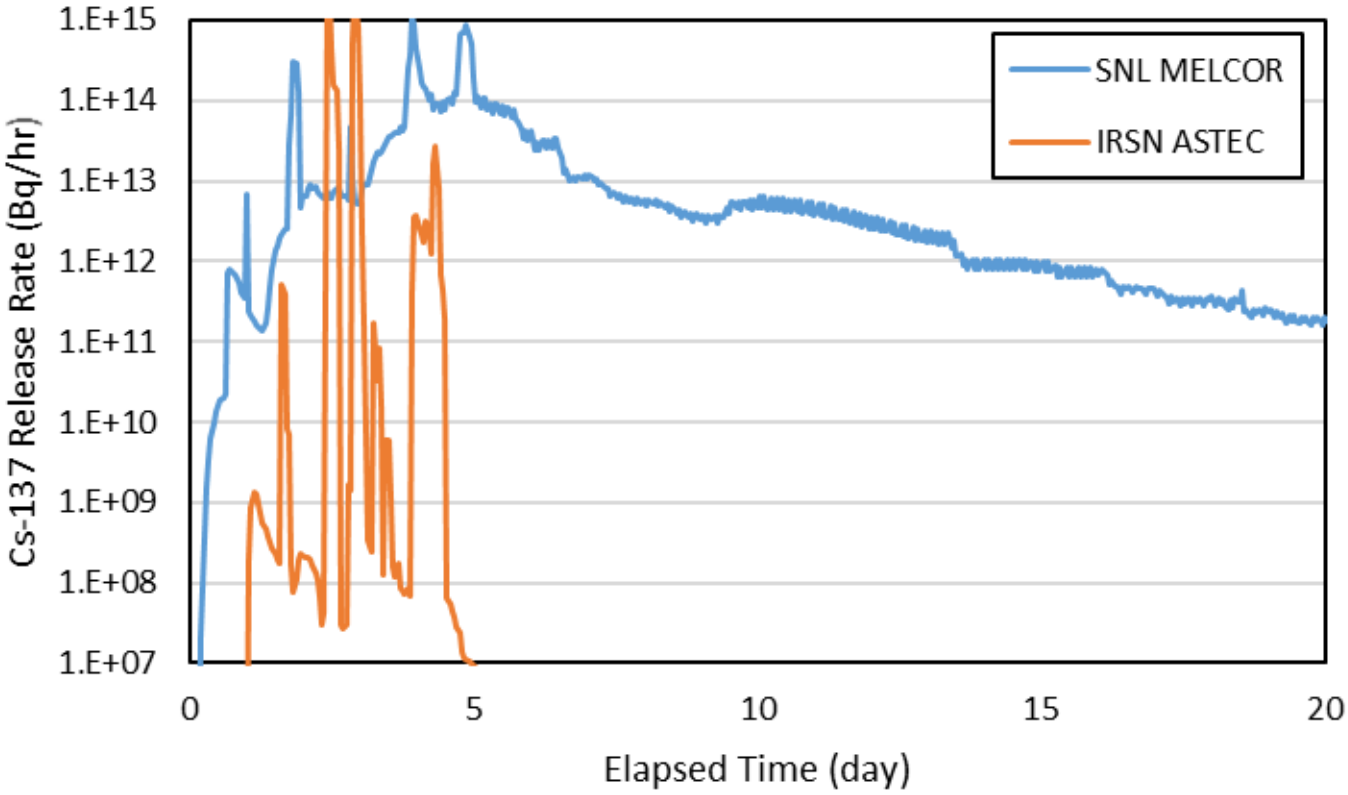




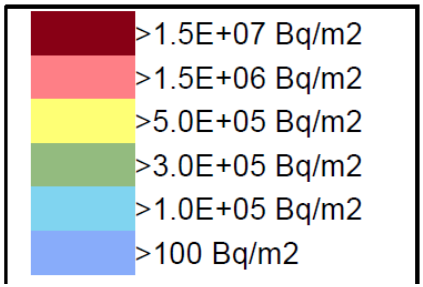


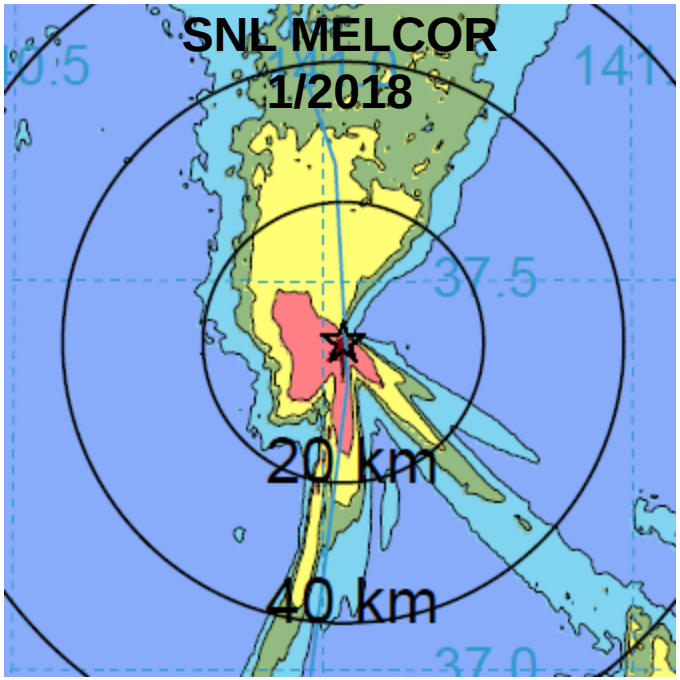


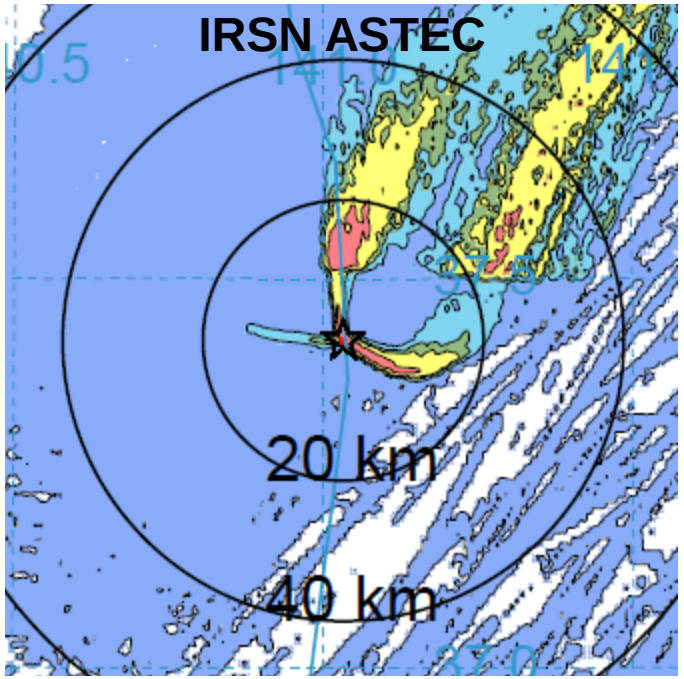
Total Source Term Comparison



Total Deposition Comparison







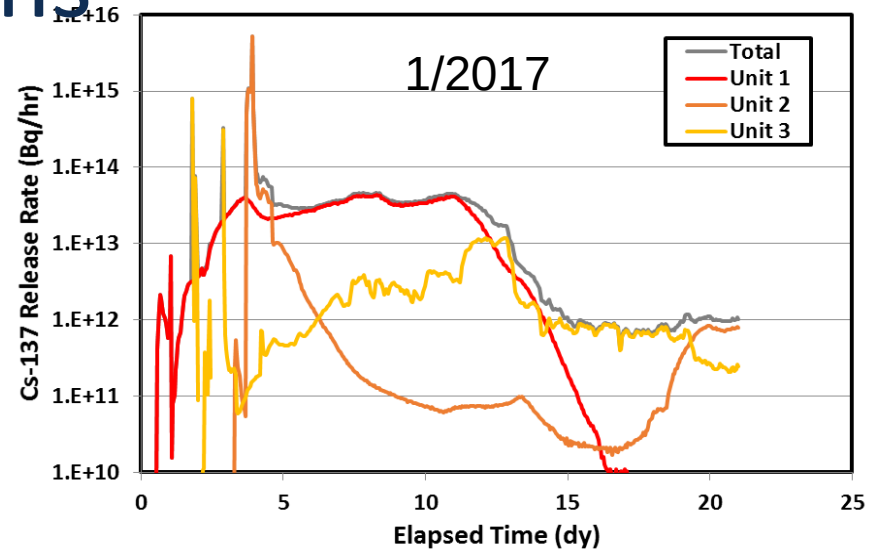
Summary

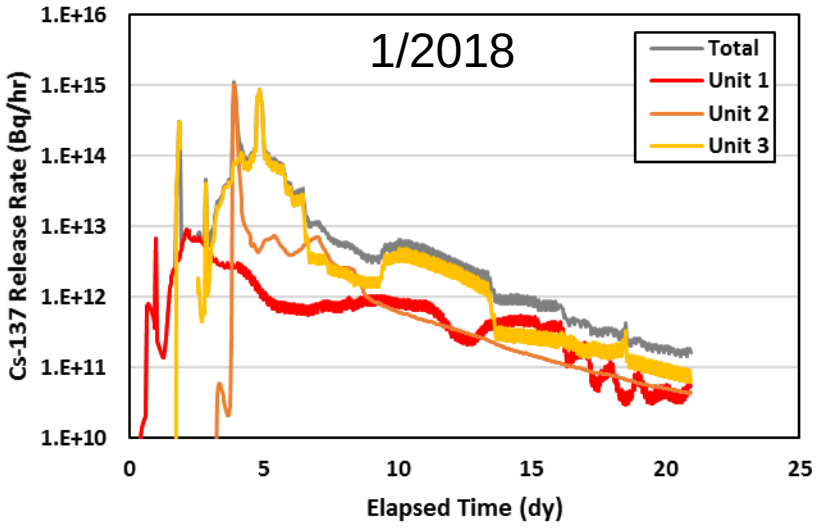
- Calculated atmospheric transport with HYSPLIT for best-estimate source term
- Investigated variation in deposition due to meteorological data variation
- Evaluated deposition pattern for five BSAF participants

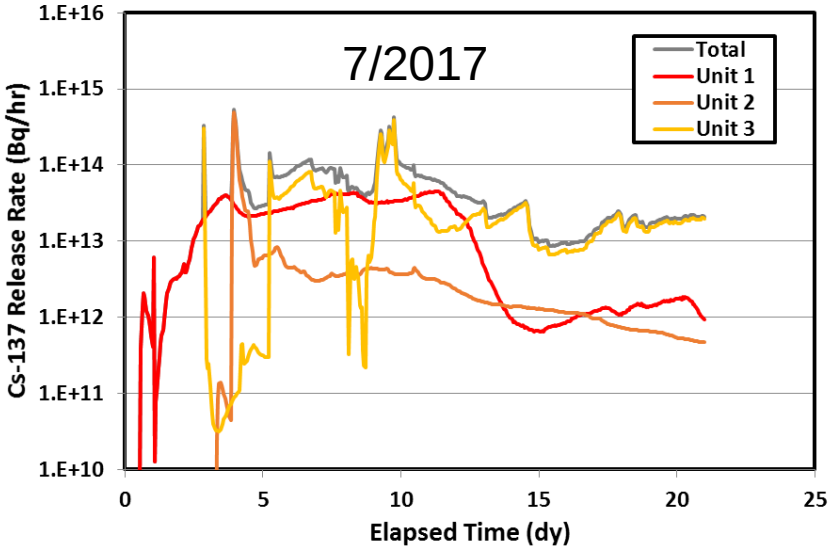
Backup

Evolution of SNL MELCOR Source Terms

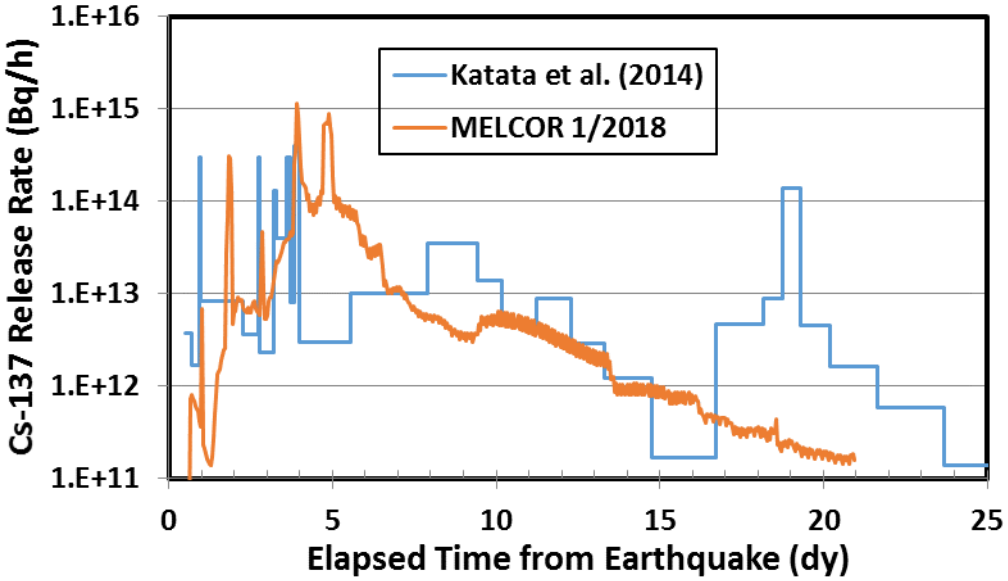
- 1/2017
  - All three units simulated for 3 weeks
  - Models account for reactor buildings
- 7/2017
  - Updated source terms with lower peaks
- Current, 1/2018
  - Further updated source terms





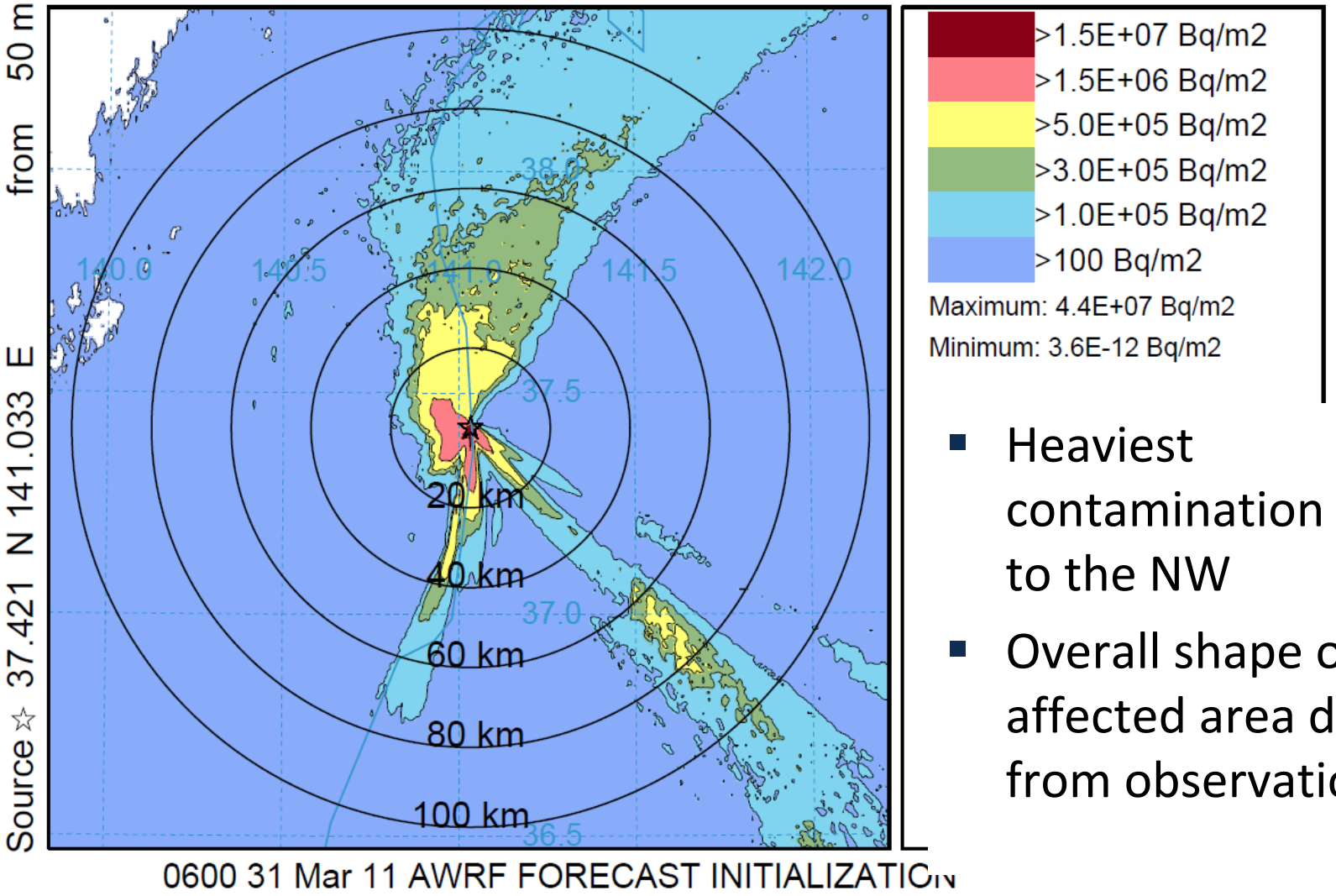


Comparison with Katata Estimate



- Several of the early release peaks reasonably match

Predicted Ground Deposition for WRF 2017 with SNL MELCOR 1/2018



- Heaviest contamination goes to the NW
- Overall shape of affected area differs from observations