NUBIKI NUCLEAR SAFETY RESEARCH INSTITUTE

Comparison of SINAC and MACCS

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WEBEX

CONTENTS

MACCS and SINAC codes main features

Benchmark input

Atmospheric dispersion results

Dose results

Conclusions

Background

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A benchmark calculation have been done for

IAEA CRP J15002

„ Effective Use of Dose Projection Tools in the Preparedness and Response to Nuclear and Radioactive Emergencies”

Main goals of study:
Comparison of main principles and capabilities of the codes
Comparison of results on a simple case

Results are used in this presentation

Introduction to the codes

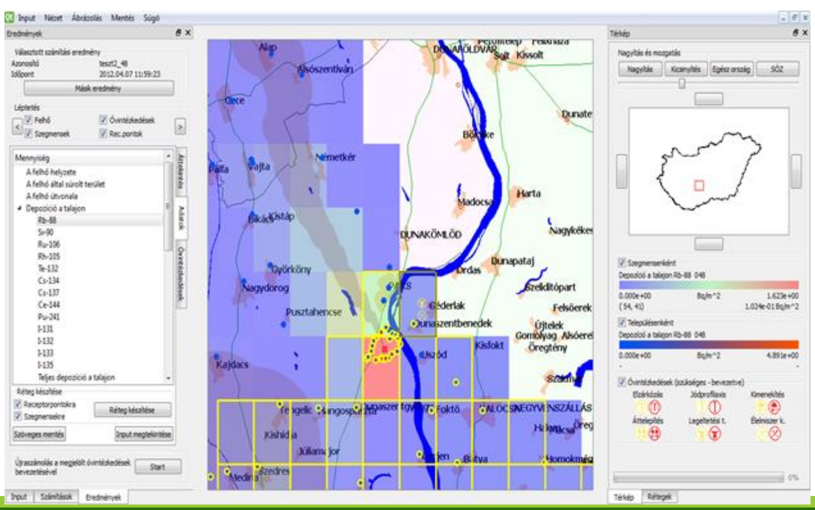
Two different accident environmental consequence codes SINAC and MACCS

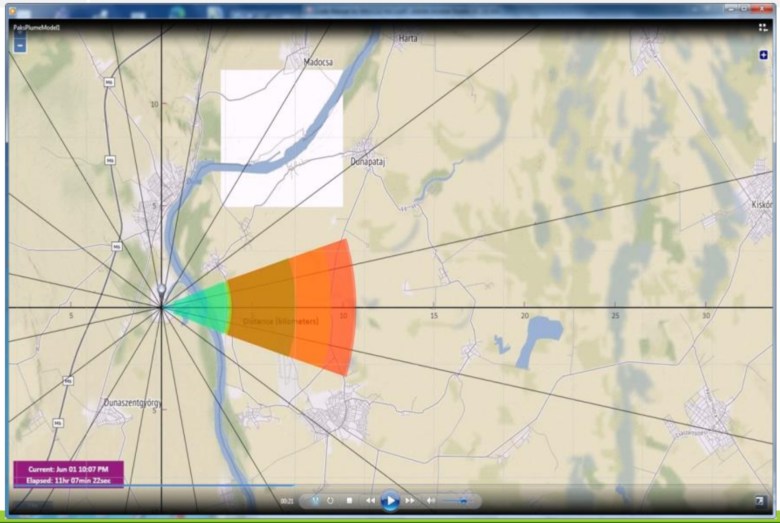
- **SINAC = S**imulator of **I**nteractive **M**odeling of environmental consequences of **N**uclear **AC**cidents code developped by the Hungarian Centre for Energy Research (CER), used by the Hungarian Atomic Energy Authority.
- The program analyses the effects of nuclear power plant accidents on the release of radioactive materials into the environment, sedimentation, emerging doses, expected health effects and recommendations for precautionary measures in the early stages of an emergency.
- MACCS = Melcor Accident Consequence Code System developed by Sandia NL for US NRC.

General comparison of two code SINAC vs. MACCS

The two codes use similar basic physical principles but there are some differences

	SINAC	MACCS
Primary application	Decision support system	Probabilistic risk assessment (PRA) tool
Used in	Hungarian Atomic Energy Authority Centre for Emergency Response	-
ADM model	Gaussian puff model	Gaussian Plume model
Coordinate system	Cartesian and geographic coordinate system	Polar-coordinate system





Comparison of input data

Source term

	SINAC	MACCS
Time of release	start date and time [UTC]	initial time of release
Activity	released activity [Bq] and chemical form [aerosol/elemental iodine/organic iodine]	release rate as a function of time (by radionuclide), chemical composition
Segments	number and timing of puffs	number of plume segments
Release characteristics	heat content, release velocity, release temperature, stack diameter	initial height of the release, buoyancy

Meteorological data

	SINAC	MACCS
Parameters	wind vector, Pasquill stability class, precipitation rate [mm/h], precipitation type	wind vector, Pasquill stability class precipitation rate [mm/h], mixing layer heights
Resolution	Fixed in time and space Time dependent, fixed in spatially NetCDF input file from Weather Service	Constant conditions 120 h of user supplied data meteorological data file

Dose calcalation method

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Calculation method of environmental spreading:

- Gaussian dispersion
  - SINAC :   Gaussian puff model
  - MACCS: straight-line Gaussian plume model

Exposure pathways in both codes:

Basically the same

Dose conversion factors:

- can be set by user in both codes
- SINAC: ICRP-116 and 119
- MACCS: ICRP-26 and 60, US.EPA Federal Guidance Reports 11, 12 and 13

Benchmark input for 9 selected radionuclides

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Parameters	SINAC	MACCS
Atmospheric dispersion model	Gaussian Puff model	Gaussian plume segment model
Time of release after SCRAM	2000.0 s	2000.0 s
Release model	duration 15000s with 1 puff per 10 minutes (25 puffs in total)	15000s
Initial value of sigma-y	9.302	9.302
Initial value of sigma-z	23.26	23.26
Particle size groups	-	2
Particle size	1 µm	1 µm
Deposition velocity	0.001 m/s aerosol 0.01 m/s elemental iodine	0.001 m/s aerosol 0.01 m/s elemental iodine
Effective release height	50 m	50 m
Heat content	0.0 W	0.0 W
Number of source terms:	1	1
Plume segments height at release (m)	0.0	0.0

Nuclide	Released activity [Bq]	Chemical form	Isotope group
Xe-133	3.51e+18	noble gas	1
I-131	7.50e+15	aerosol	2
I-131e	1.50e+16	elemental iodine	2
I-132	9.50e+15	aerosol	2
I-132e	1.89e+16	elemental iodine	2
Te-132	1.37e+16	aerosol	4
Cs-134	2.69e+15	aerosol	3
Cs-136	6.37e+14	aerosol	3
Cs-137	2.06e+15	aerosol	3

Benchmark input (cont.)

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Meteorological data

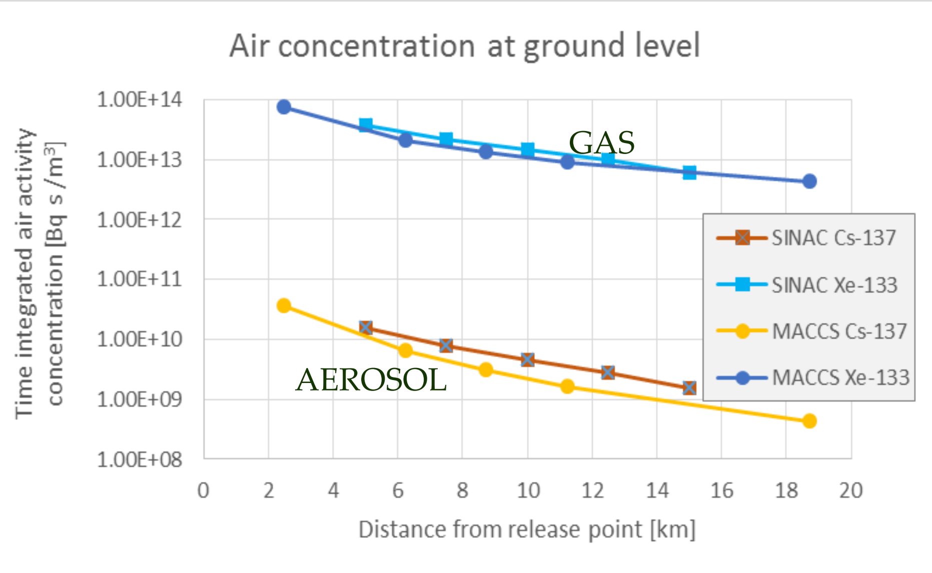
Parameters	SINAC	MACCS
Meteorological conditions	Fixed (both spatially and temporally)	4, Constant met (Boundary weather used from the start),
Wind speed	1 m/s	1 m/s
Wind direction	0° (wind blowing from North to South)	0° (wind blowing from North to South)
Precipitation rate	1 mm/h (constant in time and space)	1 mm/h (constant in time and space)
Atmospheric stability	Pasquill D class	D-Stability
Mixing Layer Height	500 m (corresponding to Pasquill D stability category)	500 m
Washout coeff. No1. linear factor	0.0001	0.0001
Washout coeff. No1. exp factor	0.8	0.8
Integration time for acute doses, d	7	7

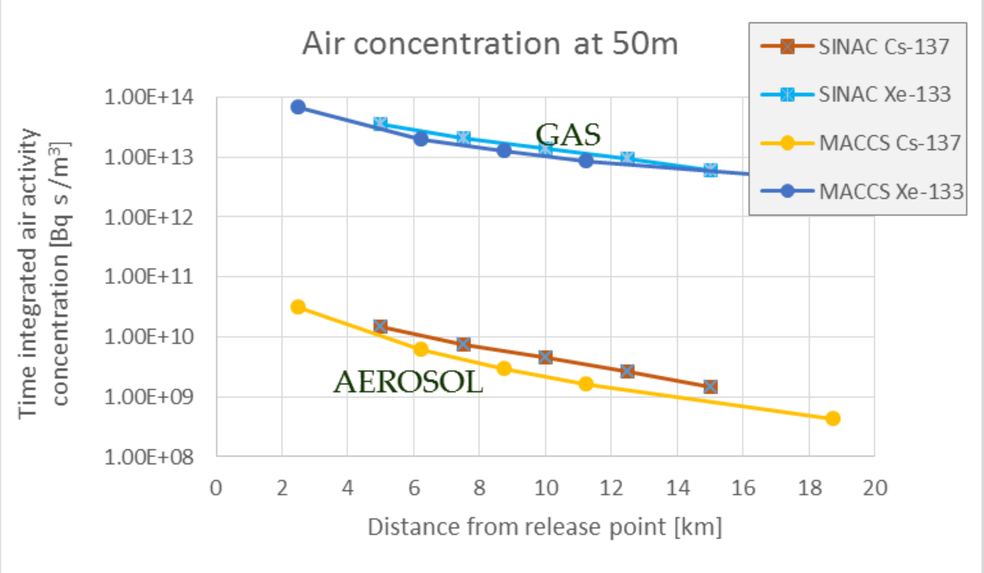
Receptor points:

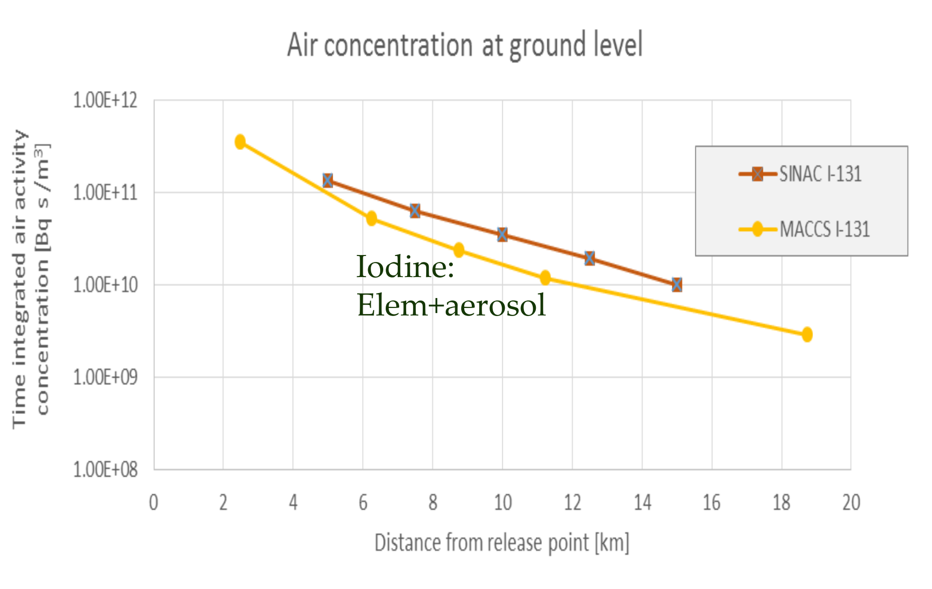
- defined along a straight line in the plume centerline
- 5.0 km, 7.5 km, 10.0 km, 12.5 km, 15.0 km

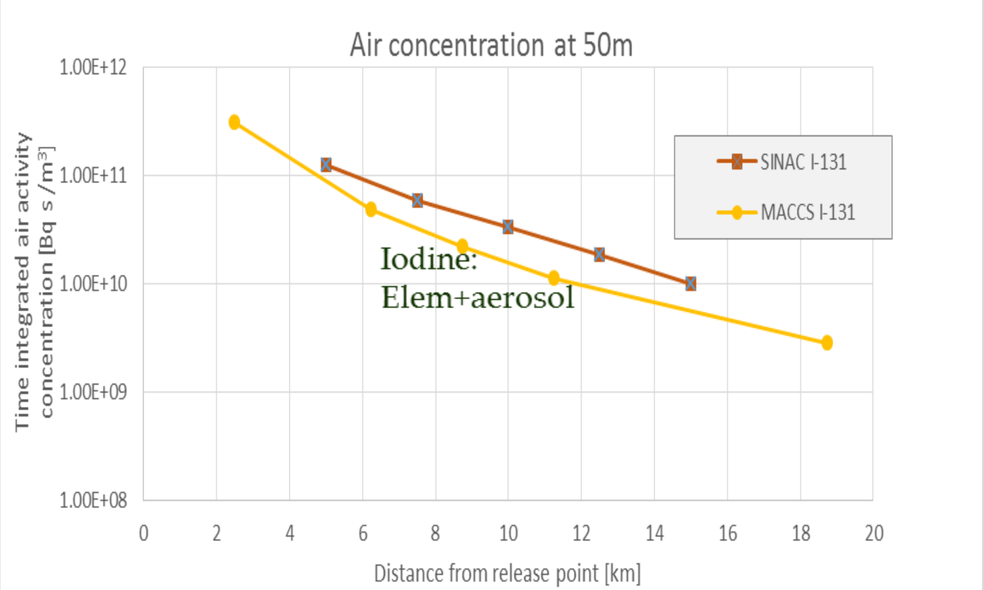
RESULTS

Atmospheric concentrations









Ground concentrations

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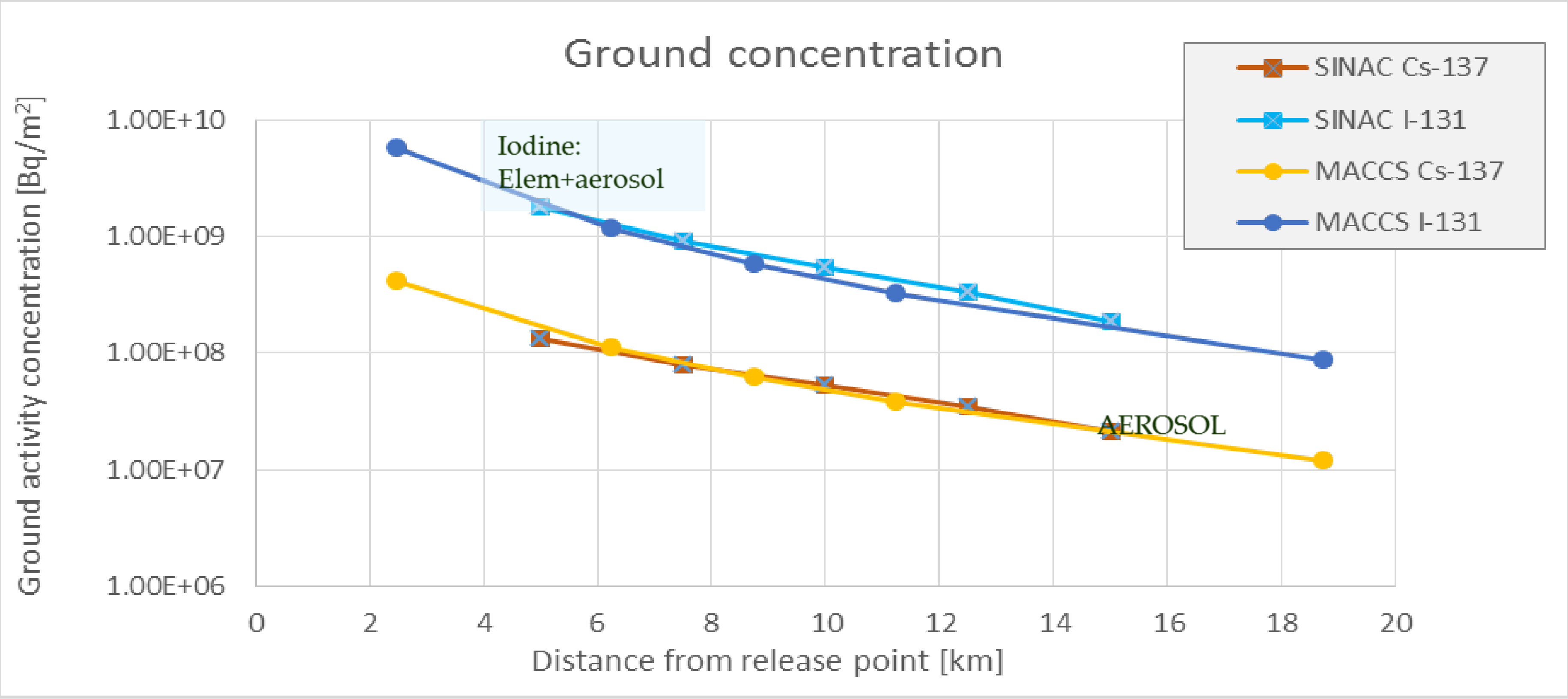

Deposition velocities, m/s

Noble gases:	0.0
Elemental Iodine:	0.01
Aerosols:	0.001

Conclusion on atmospheric dispersion

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Atmosphere : Gases and aerosols:

- Results are in the same order of magnitude
- Agreement on short distances is good
- Later disagreement is
  - SINAC gives larger air acivity concentrations
    - appr. 10% for gases
    - 2 times for aerosols
- SINAC usually gives the higher values
- In both codes the atm. concentrations are close to homogenous distribution concerning ground and elevated concentrations

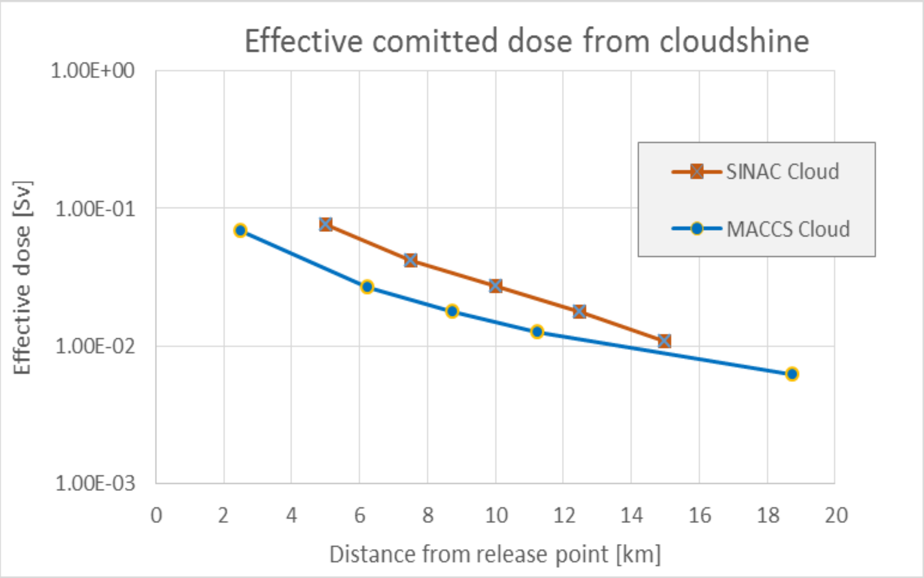
Atmosphere : Iodine

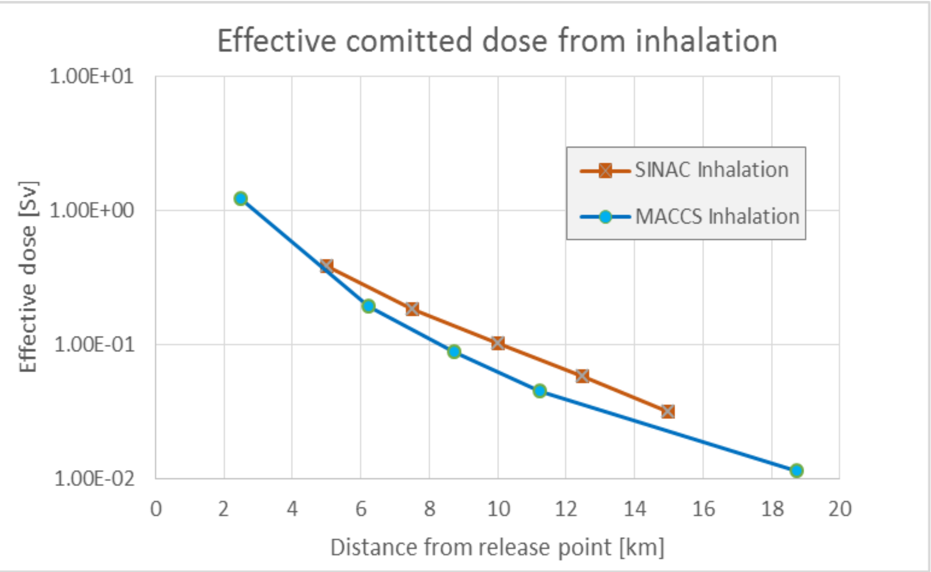
- Differences are larger on longer distances
- SINAC gives larger air iodine concentrations (similar to aerosols)

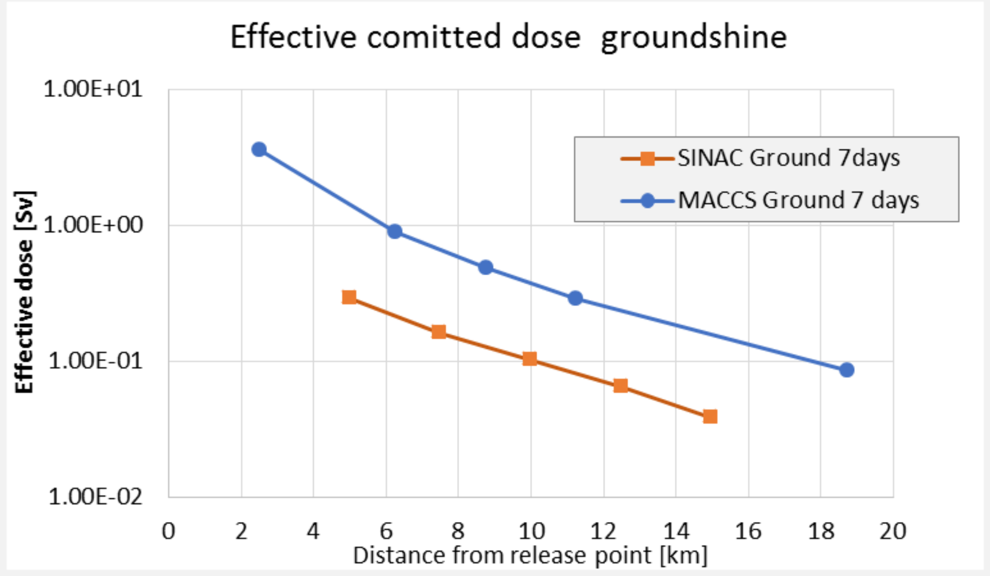
Deposition:

- Results agree well on aerosols
- Iodine agrees despite differences in atmosphere conc.

Dose results







Conclusion on Effective Committed Doses

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SINAC vs. MACCS

- **Cloudshine and inhalation doses** are higher in SINAC - consistent with higher plume air concentrations

- **Groundshine doses** are higher in MACCS which are attributed to higher Dose Conversion Factors (DCF) used

- **Mostly similar results of these base case calculations with the two codes justifies the conclusion that variation calculations to be done with the two codes will provide believable range of uncertainties in predictions.**

THANK you for your attention!