A benchmark analysis between RASCAL and HYSPLIT simulation results and field measurements

A. Janés, P. Díaz – IDOM

R. Arasa, I. Porras, M. González - METEOSIM



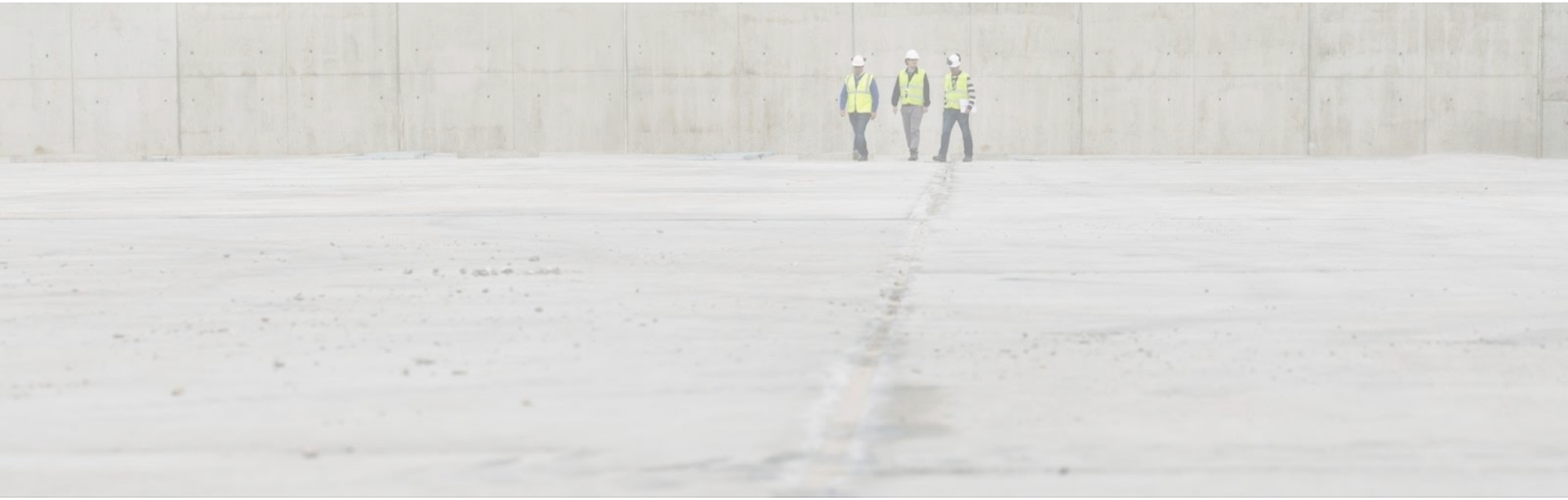
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Introduction



New tool for evaluating consequences of an accidental atmospheric release of radioactive material

Computer codes currently used to evaluate radiological consequences:

Emergencies:

- **RASCAL** (NUREG-1925): Radiological Assessment System for Consequence AnaLysis, used by the Protective Measures Team in the U.S. Nuclear Regulatory Commission's (NRC's) Operations Center for making independent dose and consequence projections during radiological incidents and emergencies.

- **MESORAD** (NUREG/CR-2500):Developed as an emergency response tool to assess the potential consequences of a radiological emergency situation (1986).

- **IRDAM** (NUREG/CR-3012): Interactive Rapid Dose Assessment Model. For rapidly assessing the radiological impact of accidents at nuclear power plants. (1983).

- **JRODOS**: An off-site emergency management system for nuclear accidents. Promoted and supported by the European Commission. Its legacy manifests through the international NERIS network (European Platform on Preparedness for Nuclear and Radiological Emergency Response and Recovery).

All of these codes use ATDM based on a straight-line Gaussian model (except JRODOS)

New tool for evaluating consequences of an accidental atmospheric release of radioactive material

Computer codes currently used to evaluate radiological consequences:

Licensing/Design purposes:

- **PAVAN** (RG 1.145): "Atmospheric Dispersion Models for potential Accident Consequence Assessments at Nuclear Power Plants".
- **XOQDOQ** (RG 1.111): "Methods for estimating transport and dispersion of gaseous effluents in routine releases from light-water reactors".
- **ARCON96** (RG 1.194): "Atmospheric Relative Concentrations for Control Room Radiological Habitability Assessments at Nuclear Power Plants".
- **RADTRAD** (NUREG/CR-6604): A Simplified Model for RADionuclide Transport and Removal And Dose Estimation (licensing assistance). No atmospheric transport modeling is performed by the code.
- **MACCS2** (NUREG/CR-4691, NUREG/CR-6613): MELCOR Accident Consequence Code Systems. A probabilistic risk assessment (PRA) tool: Cost-benefit analyses for 1st time licensees or license extension; L3PSA; Used in a study to risk-inform emergency response guidance in the U.S. and to support the licensing of a nuclear power plant in Argentina; State of the Art Reactor Consequence Analysis, (to assess the safety of existing power plants); It's one of the DOE toolbox codes developed to perform analyses to demonstrate the site boundary doses are below a regulatory limit; widely used to assess the safety of DOE's nuclear facilities.

All of these codes use ATDM based on a straight-line Gaussian mode

New tool for evaluating consequences of an accidental atmospheric release of radioactive material

Goals

1.Improve ATDM codes normally used by nuclear industry for emergency response purposes

2.Improve the quality and accuracy of the meteorological data used as input to run the ATDM model.

3.Provide the best possible estimate and prediction of the source term combining L2PSA and measurements (Inverse modelling / backward trajectories)

4.Provide a modular and flexible tool, with a user-friendly interface and a versatile platform

Main applications

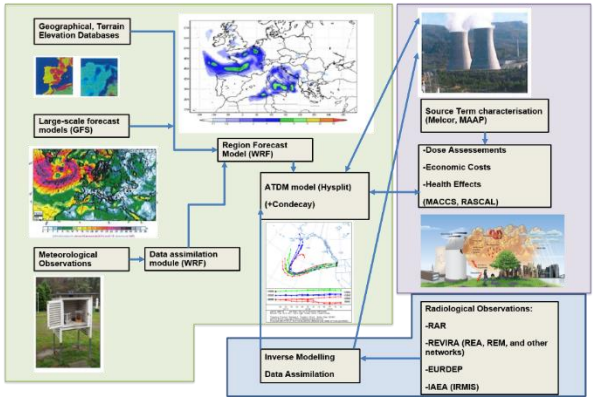
Radiological evaluation of NPP accidents for emergency response

Cost-benefit analyses for NPP applying for a license (1st or a license extension)

L3PRA Assessments

Assessment of nuclear fuel cycle and other radioactive facilities accidents

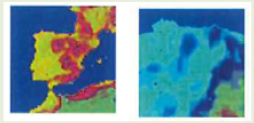
Assessment of routinely releases, bomb detonations, derelict satellites, and exposition to theft/lost radioactive sources accidents



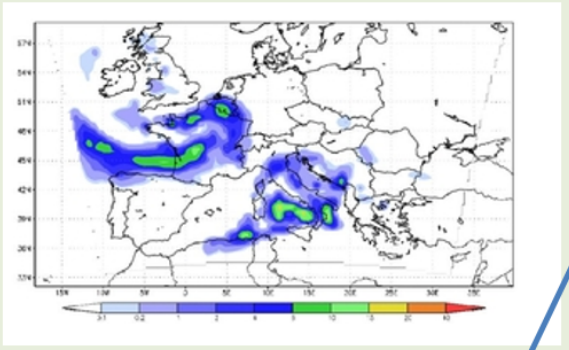
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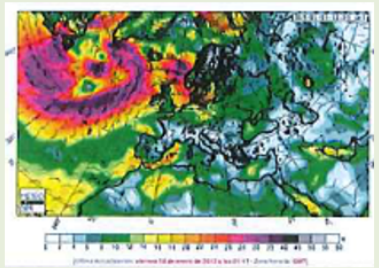
Geographical, Terrain Elevation Databases



Large-scale forecast models (GFS)

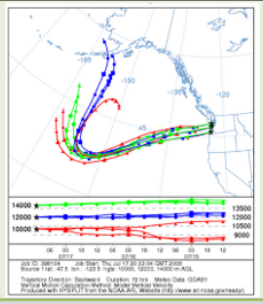


Region Forecast Model (WRF)



ATDM model (Hysplit)

(+Condecay)



Meteorological Observations

Data assimilation module (WRF)





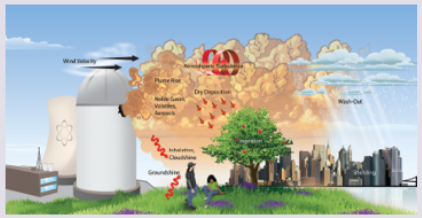
Source Term characterisation (Melcor, MAAP)

-Dose Assessements

-Economic Costs

-Health Effects

(MACCS, RASCAL)



Inverse Modelling

Data Assimilation

Radiological Observations:

-RAR

-REVIRA (REA, REM, and other networks)

-EURDEP

-IAEA (IRMIS)

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New tool for evaluating consequences of an accidental atmospheric release of radioactive material

HYSPLIT

HYSPLIT: Hybrid Single-Particle Lagrangian Integrated Trajectory

Developed by: NOAA ARL Draxler and Taylor

HYSPLIT is one of the ATDM considered for emergency management by the World Meteorological Organization (WMO)







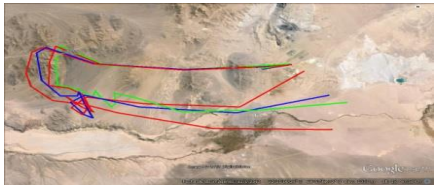
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HYSPLIT

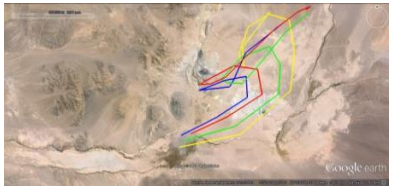
HYSPLIT: Hybrid Single-Particle Lagrangian Integrated Trajectory

Trajectories



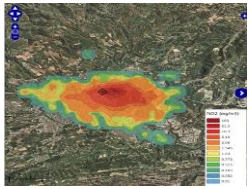
HYSPLIT provides the path followed by a determined contaminant that has been released from a specific location. It allows to identify those areas that could be affected by a determined activity

Backward trajectories



HYSPLIT provides information about the source of the air mass that affects a specific location. Hence, it allows to analyze possible sources of contaminants.

Dispersion

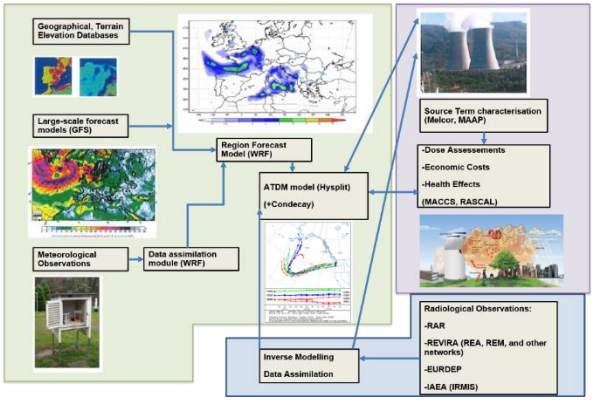


HYSPLIT provides information about the atmospheric dispersion of a specific element.

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Added Values



Couple in one system the most used meteo model worldwide (WRF) with a model tested for nuclear applications and used by different national emergency response organizations (HYSPLIT)

Reduce the contribution of meteo to the global uncertainty of this kind of systems because the model can be configured to **reproduce specific meteo conditions** of any part of the world doing **a specific calibration**

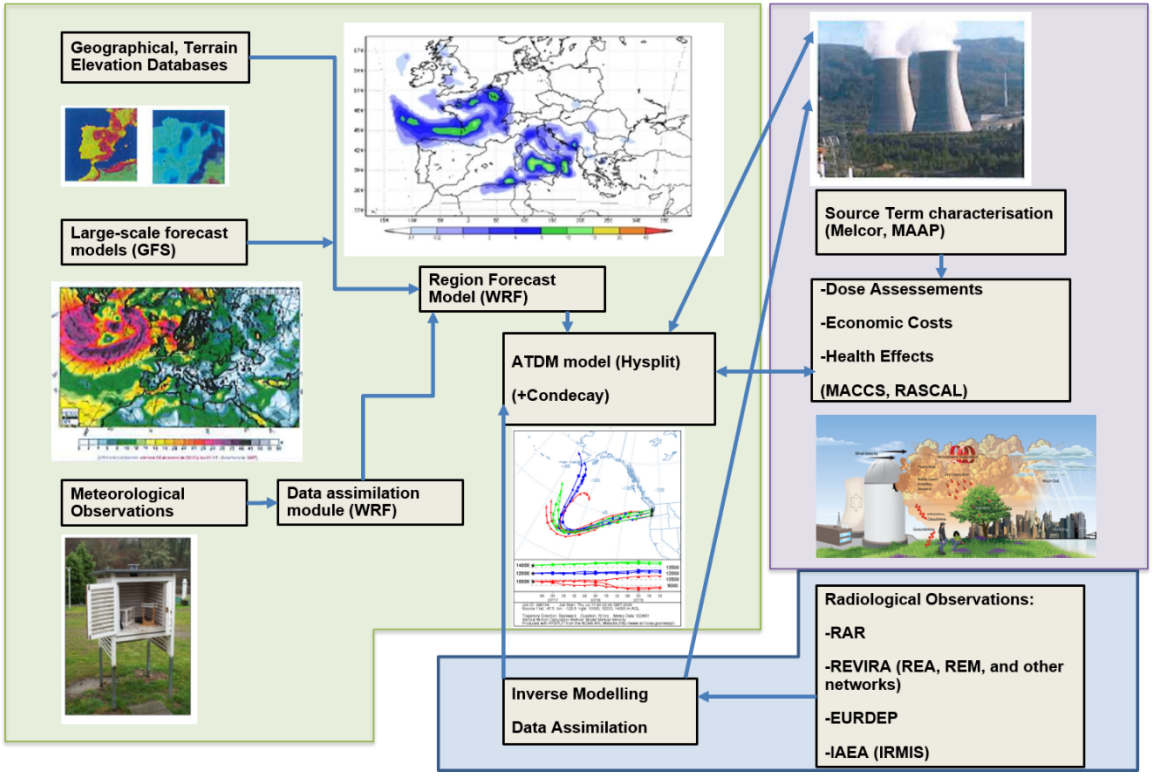
Flexible system, easy to use in an operative way. All the models within the system can be coupled among them and can be prepared to run automatically without human interaction.

Capacity to run the system for diagnostic and prognostic.

Short response time. In case of emergency the system proposed provides a response in less than 1 min. This time corresponds to the HYSPLIT simulation because WRF is running all the year with up to 6 daily updates.

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Development

Today's presentation

Short-term: Benchmark between HYSPLIT and a validated code for NPP radiological release evaluation

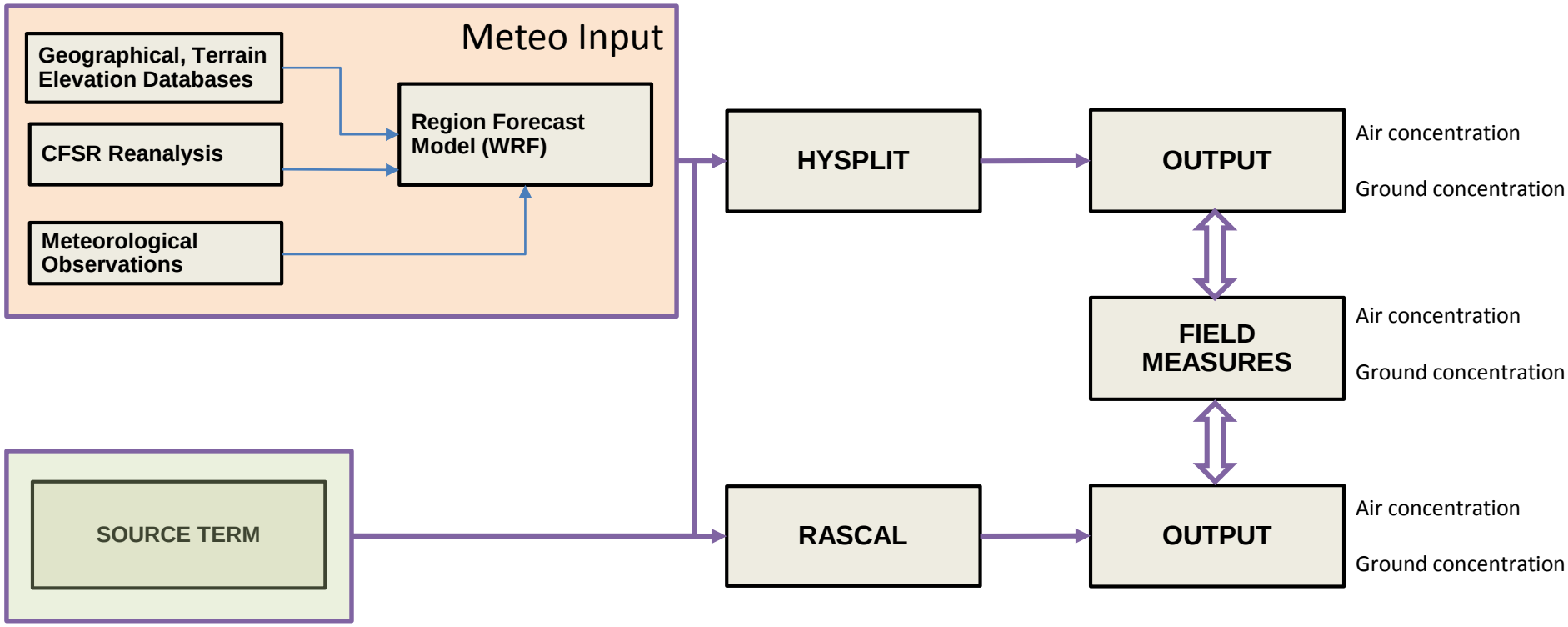
Medium-term: Development of the tool modules: source term and dose assessment, among others

Long-term: Inverse modelling / backward trajectories

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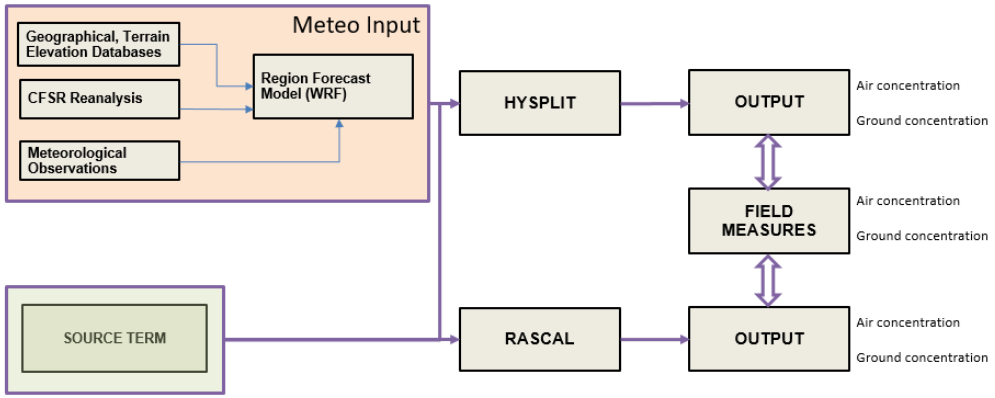
BENCHMARK



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BENCHMARK



Goals

To put to test the following hypothesis:

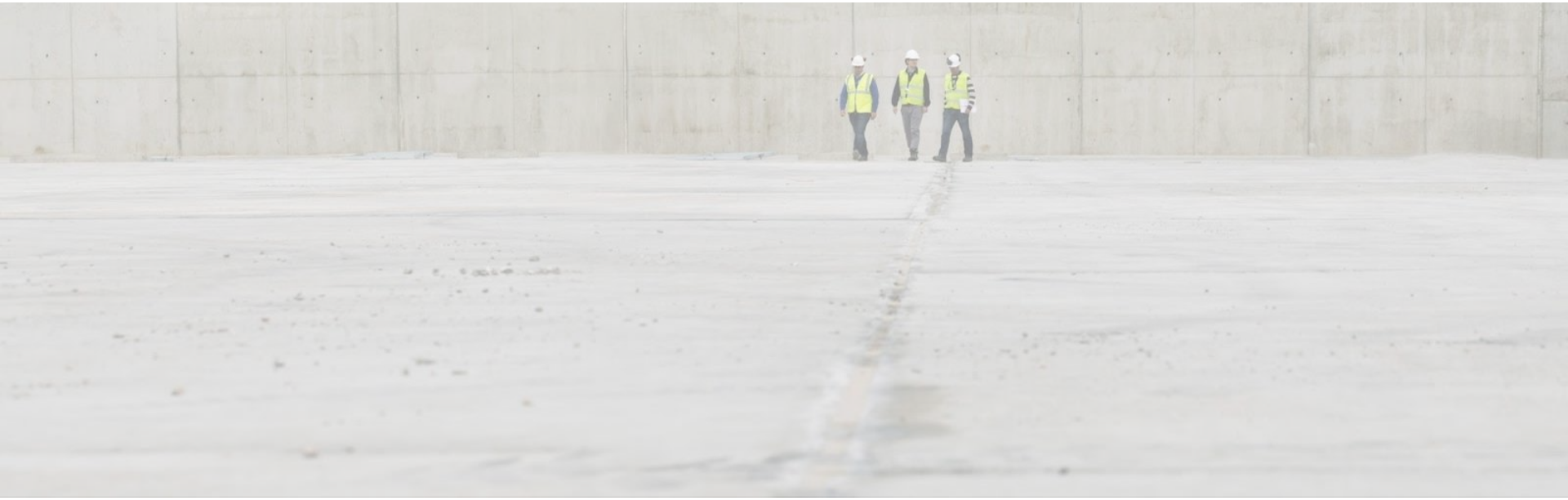
- HYSPLIT output is more accurate than that of currently used codes

Why RASCAL

- Widely used code for emergency preparation purposes amongst nuclear operators and regulators
- Provides output of I-131 air and ground concentration
- User-friendly interface

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Case of study



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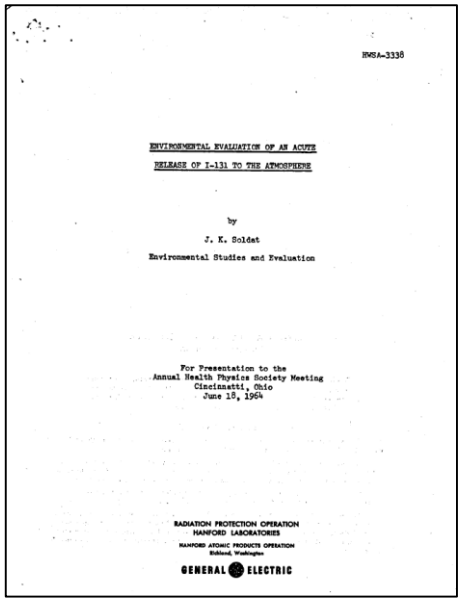
Description of the case

Location: Hanford Site, WA

Time: September 1963

Radionuclides released: I-131

Meteo: not available



HWSA-3338

ENVIRONMENTAL EVALUATION OF AN ACUTE RELEASE OF I-131 TO THE ATMOSPHERE

by

J. K. Soldat

Environmental Studies and Evaluation

For Presentation to the Annual Health Physics Society Meeting Cincinnati, Ohio June 18, 1964

RADIATION PROTECTION OPERATION HANFORD LABORATORIES

HANFORD ATOMIC PRODUCTS OPERATION Richland, Washington

GENERAL ELECTRIC

REF: HWSA-3338

Source term

Table 6.1. Release Rate of Iodine-131 to the Atmosphere from the September 1963 PUREX Plant Release Event[a]

Date	Time	^{131}I Activity Released (Ci)
September 2	12:25 - 16:25	5.5
September 2	16:25 - 23:30	18.5
September 2-3	23:30 - 09:10	22.3
September 3	09:10 - 11:55	3.9
September 3	11:55 - 15:05	2.3
September 3	15:10 - 23:30	5.3
September 3	23:30 - 08:50	2.3
September 4	08:50 - 15:00	1.3
September 4-5	15:00 - 09:10	1.1
September 5	09:10 - 14:45	0.21
September 5-6	14:45 - 00:30	0.16
September 6	00:30 - 09:00	0.18
September 6	09:00 - 14:25	0.095
September 6-7	14:25 - 09:00	0.23
September 7	09:00 - 15:20	0.11
September 7-8	15:20 - 14:00	0.37
September 8-9	14:00 - 09:00	0.29
September 9-10	09:00 - 09:15	0.36
September 10-11	09:15 - 09:00	0.35
to Sept. 30		7 ± 2
Total[b]		72 ± 2

(a) Hourly data from handwritten record by J. K. Soldat, then an employee of General Electric Company.
(b) Monthly total (72 Ci) from Foster (1963, p. 3) estimated as monthly average of 2.4 Ci/day times 30 days. Total for September 12-30 determined by subtraction.

REF: PNWD-2221 HEDR

Acute release of I-131 from the 2nd - 6th of September

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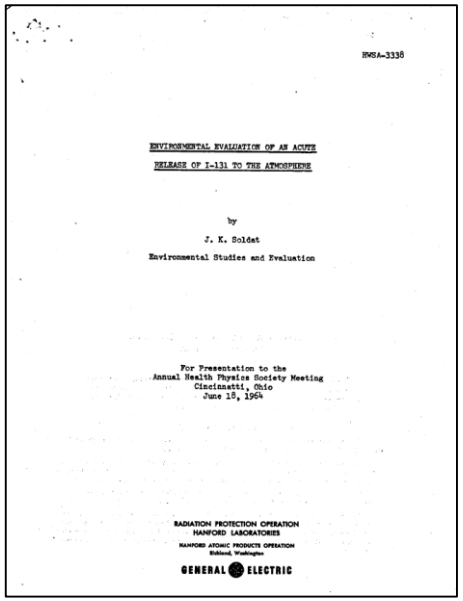
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Source term

I-131

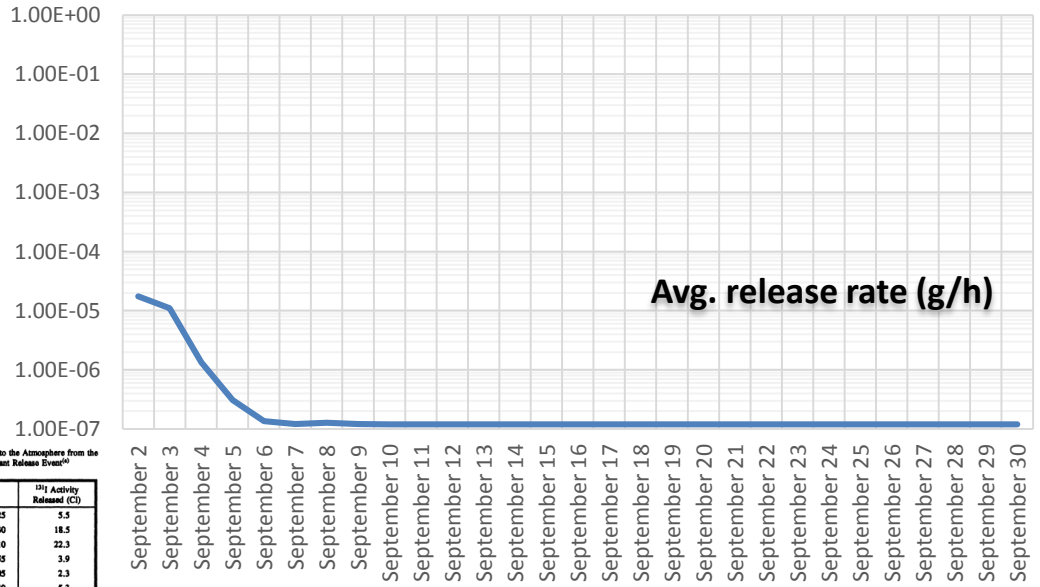


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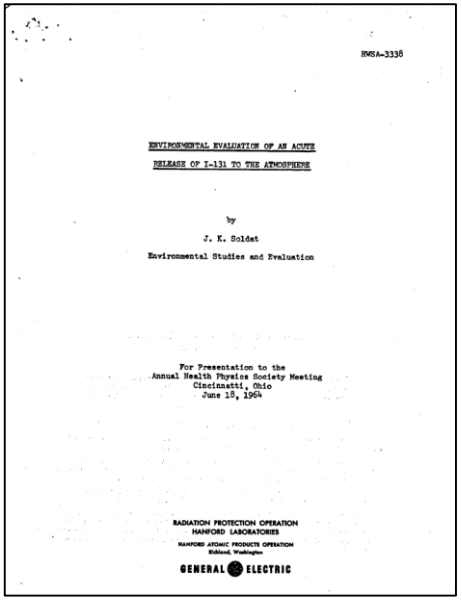
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Data
Maximum concentration for a specified time period



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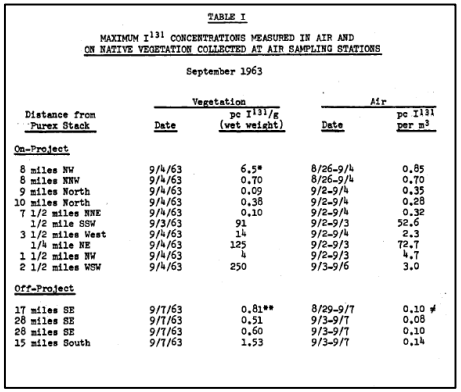


TABLE I

MAXIMUM I^{131} CONCENTRATIONS MEASURED IN AIR AND ON NATIVE VEGETATION COLLECTED AT AIR SAMPLING STATIONS

September 1963

Distance from Purex Stack	Vegetation Date	Vegetation pc I^{131}/g (wet weight)	Air Date	Air pc I^{131} per m^3
On-Project				
8 miles NW	9/4/63	6.5*	8/26-9/4	0.85
8 miles NNW	9/4/63	0.70	8/26-9/4	0.70
9 miles North	9/4/63	0.09	9/2-9/4	0.35
10 miles North	9/4/63	0.38	9/2-9/4	0.28
7 1/2 miles NNE	9/4/63	0.10	9/2-9/4	0.32
1/2 mile SSW	9/3/63	91	9/2-9/3	52.6
3 1/2 miles West	9/4/63	14	9/2-9/4	2.3
1/4 mile NE	9/4/63	125	9/2-9/3	72.7
1 1/2 miles NW	9/4/63	4	9/2-9/3	4.7
2 1/2 miles WSW	9/4/63	250	9/3-9/6	3.0
Off-Project				
17 miles SE	9/7/63	0.81**	8/29-9/7	0.10 ¥
28 miles SE	9/7/63	0.51	9/3-9/7	0.08
28 miles SE	9/7/63	0.60	9/3-9/7	0.10
15 miles South	9/7/63	1.53	9/3-9/7	0.14

REF: HWSA-3338

Field measurements

ID	Measure point*	Date	pCi I-131 / m^3
1	8 miles NW	**8/26 - 9/4**	0,85
2	8 miles NNW	**8/26 - 9/4**	0,7
3	9 miles North	**9/2 - 9/4**	0,35
4	10 miles North	**9/2 - 9/4**	0,28
5	7,5 miles NNE	**9/2 - 9/4**	0,32
6	0,5 miles SSW	**9/2 - 9/3**	52,6
7	3,5 miles West	**9/2 - 9/4**	2,3
8	0,25 miles NE	**9/2 - 9/3**	72,7
9	1,5 miles NW	**9/2 - 9/3**	4,7
10	2,5 miles WSW	**9/3 - 9/6**	3
11	17 miles SE	**8/29 - 9/7**	0,1
12	28 miles SE	**9/3 - 9/7**	0,08
13	28 miles SE	**9/3 - 9/7**	0,1
14	15 miles South	**9/3 - 9/7**	0,14
15	19 miles ESE	**9/2 - 9/4**	0,15
16	21 miles SSE	**9/3 - 9/7**	0,24
17	18 miles South	**9/3 - 9/7**	0,14
18	19 miles South	**9/3 - 9/7**	0,14
19	20 miles South	**9/3 - 9/7**	0,14
20	20 miles SE	**8/29 - 9/3**	0,14
21	24 miles SE	**9/3 - 9/7**	0,10
22	28 miles SE	**9/3 - 9/7**	0,08
23	31 miles SE	**9/3 - 9/7**	0,1

Highest

***Distance from Hanford Site stack**

Time periods between 9/2 and 9/7

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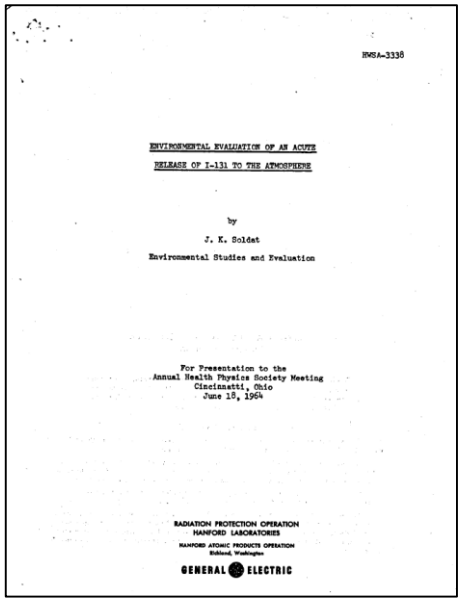
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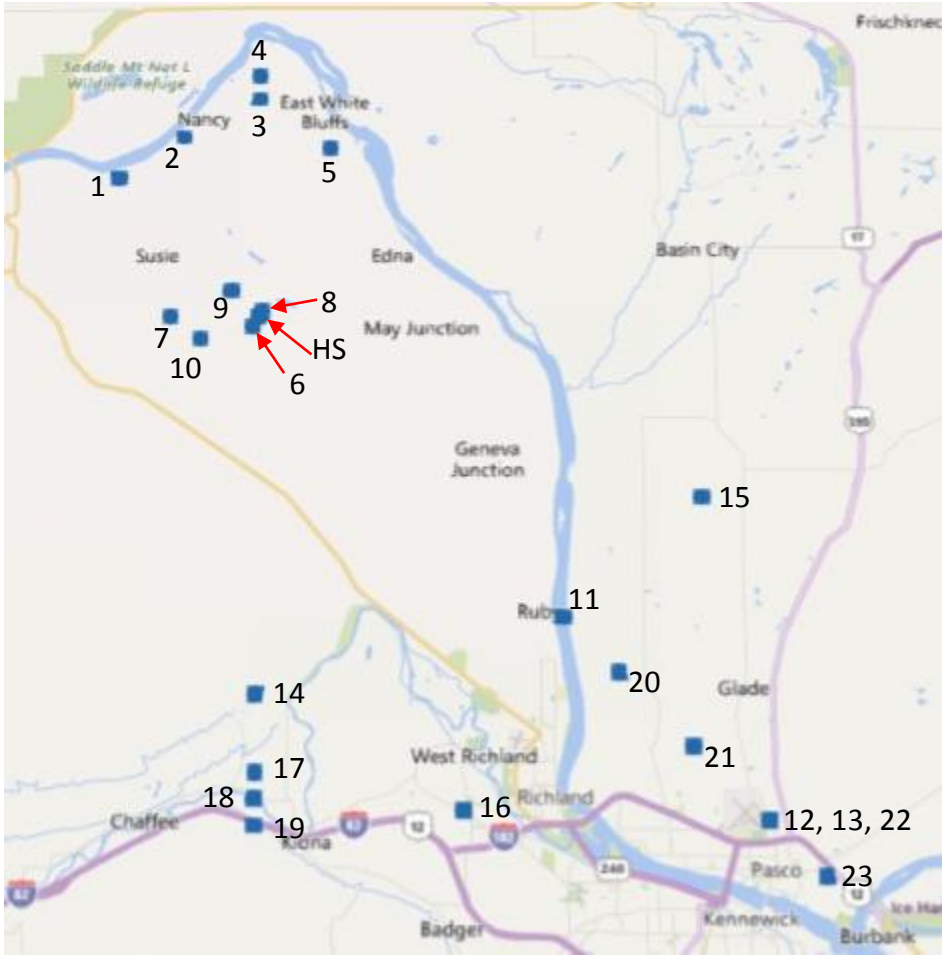
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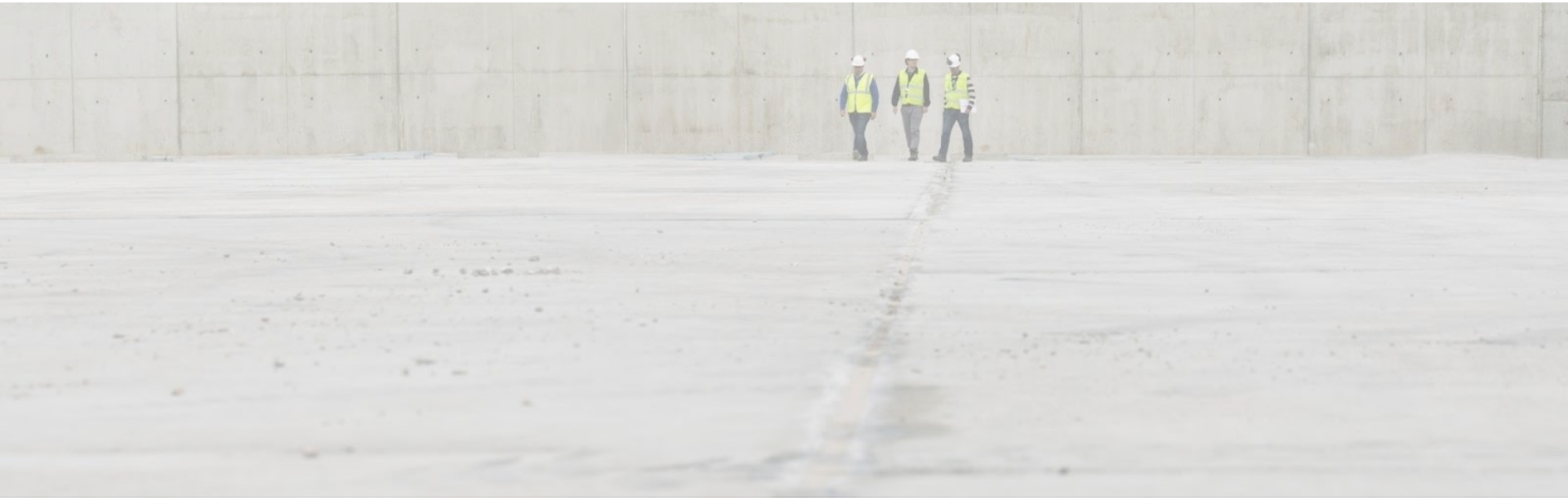
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Field measurements



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Meteo data

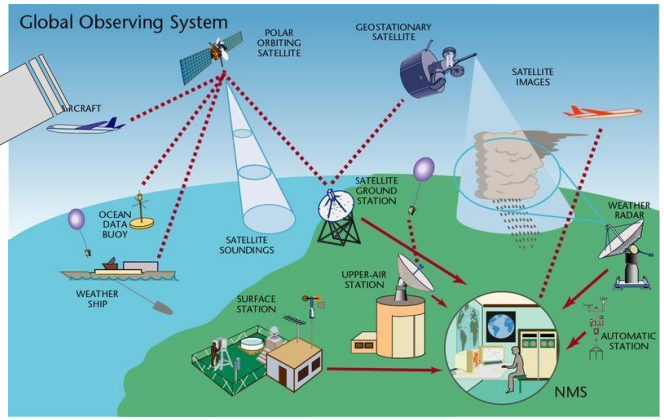


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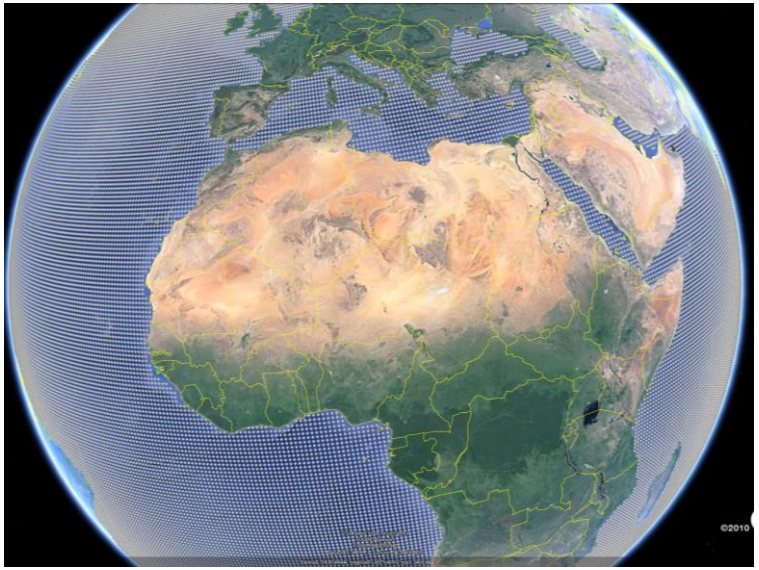
September 1963 available meteo data at HS surroundings is limited → WRF-ARW Simulation

Mesoscale model

GDAS



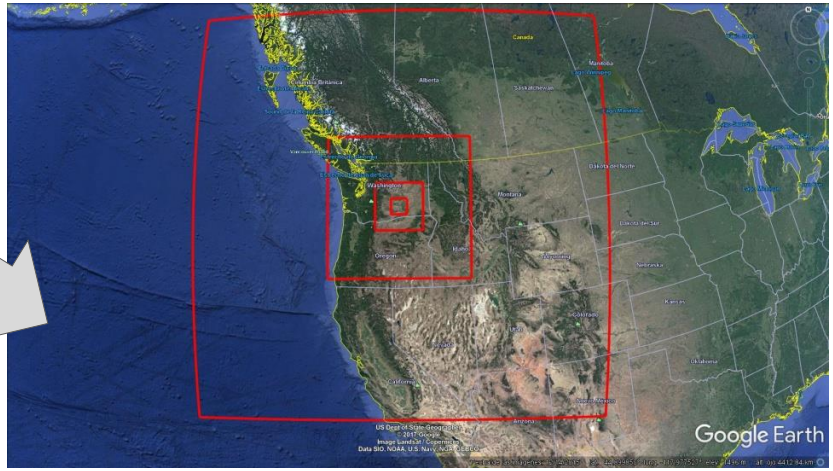
CFSR Reanalysis (NOAA)



Reanalysis is the best historical weather representation because it incorporates a high amount of observations and measurements

It can be coupled to WRF

WRF-ARW



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New tool for evaluating consequences of an accidental atmospheric release of radioactive material

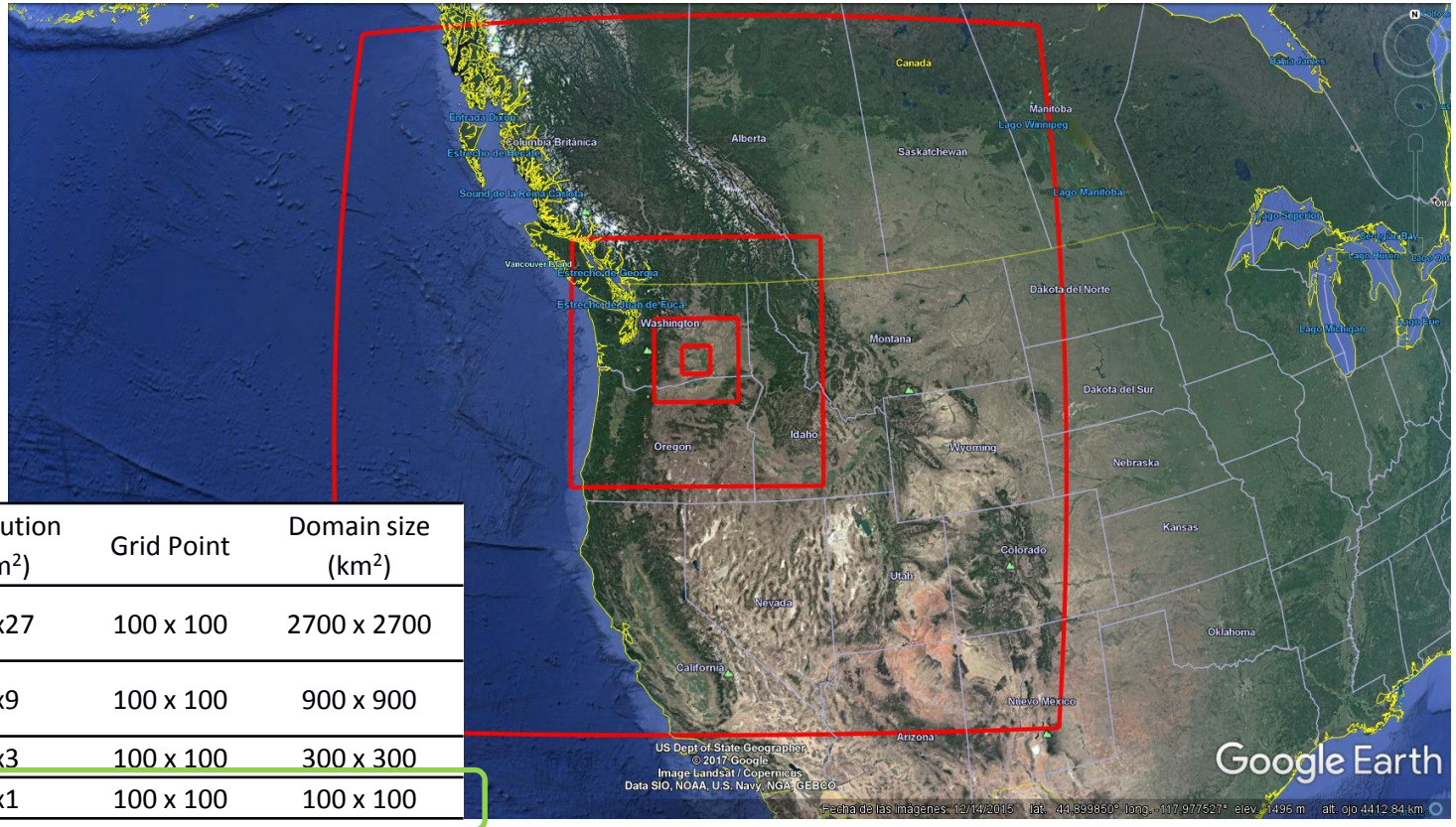
September 1963 available meteo data at HS surroundings is limited → WRF-ARW Simulation

Mesoscale model

WRF-ARW

Scalable and adaptable to the area of study

Center
46.55ºN
119.5ºW



Domain	Resolution (km²)	Grid Point	Domain size (km²)
D01	27x27	100 x 100	2700 x 2700
D02	9x9	100 x 100	900 x 900
D03	3x3	100 x 100	300 x 300
D04	1x1	100 x 100	100 x 100

Added value: 1x1 km² resolution for the meteo data of the region of interest

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New tool for evaluating consequences of an accidental atmospheric release of radioactive material

September 1963 available meteo data at HS surroundings is limited → WRF-ARW Simulation (Mesoscale model)

WRF-ARW model validation
Model vs Observations

Model run:

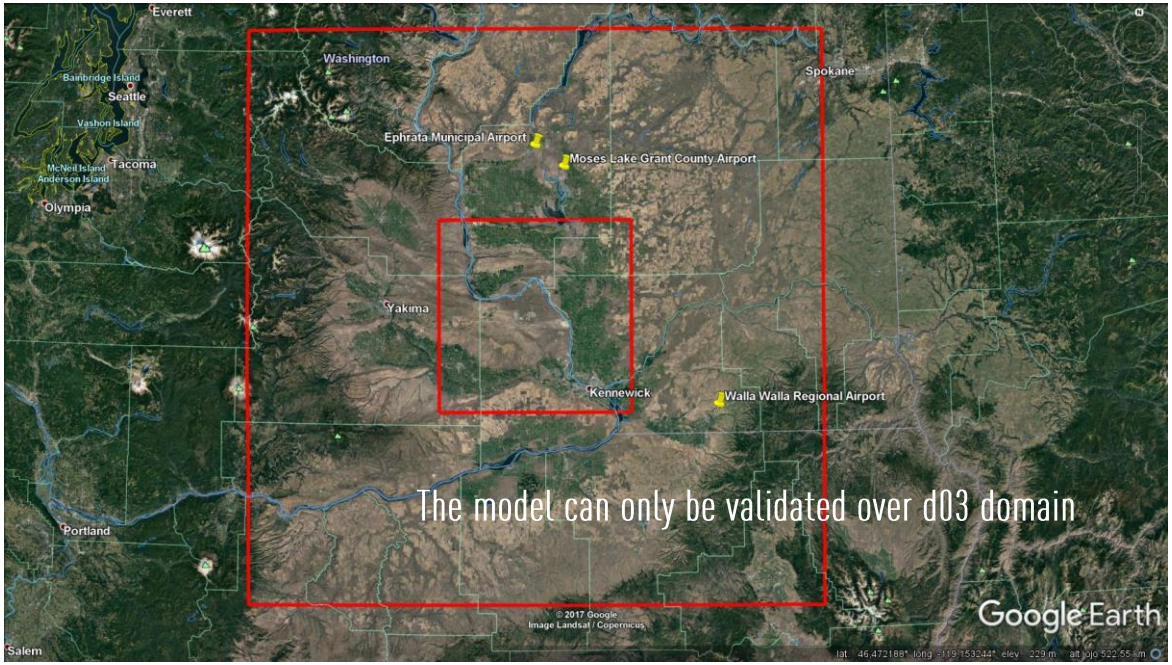
September the 1st to September the 30th for 1980-2010

Observations:

Ephrata Municipal Airport
(47.3079ºN 119.5154ºW)

Moses Lake Grant County Airport
(47.20778ºN 119.31917ºW)

Walla Walla Regional Airport
(46.09472ºN 118.28694ºW)



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New tool for evaluating consequences of an accidental atmospheric release of radioactive material

September 1963 available meteo data at HS surroundings is limited → WRF-ARW Simulation

Mesoscale model

WRF-ARW model validation

Model vs Observations

Model run (d03):

September the 1st to September the 30th for 1980-2010

Observations:

Ephrata Municipal Airport (47.3079ºN 119.5154ºW)

Moses Lake Grant County Airport (47.20778ºN 119.31917ºW)

Walla Walla Regional Airport (46.09472ºN 118.28694ºW)

Results are **reasonably good** considering both the long period of analysis (30 years) and the fact that the highest resolution model has not been used

Meteorological parameter (reference height)	Statistic (Recommendation)	Ephrata Municipal Airport	Grant County International Airport	Walla Walla Regional Airport	All stations*
Wind speed (10 m)	MB ($<\pm0.5 ms^{-1}$)	-0.53 ms^{-1}	-0.20 ms^{-1}	-1.02 ms^{-1}	-0.60 ms^{-1}
	RMSE ($<2.0 ms^{-1}$)	2.22 ms^{-1}	1.93 ms^{-1}	1.84 ms^{-1}	2.00 ms^{-1}
	IOA (≥0.60)	0.67	0.67	0.67	0.67
Wind direction (10 m)	MB ($<\pm10°$)	0º	15º	17º	10º
	MAGE ($<30°$)	47º	47º	43º	46º

The model tends to slightly underestimate the wind speed

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New tool for evaluating consequences of an accidental atmospheric release of radioactive material

September 1963 available meteo data at HS surroundings is limited → WRF-ARW Simulation (Mesoscale model)

WRF-ARW representative year — Deciding the data to be used in HYSPLT and RASCAL

1. All those years where the model best fits the observed date are analyzed

2. September 1963 observed data (Walla Walla and Grant County) is compared to model results for the years selected

Year	RMSE (m/s)	MAGE (°)
1981	1.97	43
1983	2.03	42
1984	2.07	25
1986	1.87	45
1989	1.98	42
1991	1.95	45
1995	1.86	45
2001	1.90	44
2004	2.04	45
2008	1.78	45

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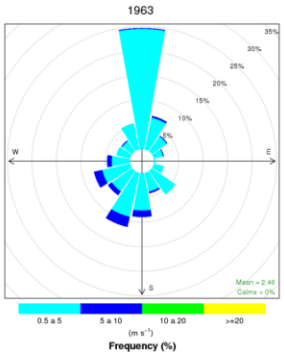
New tool for evaluating consequences of an accidental atmospheric release of radioactive material

September 1963 available meteo data at HS surroundings is limited → WRF-ARW Simulation

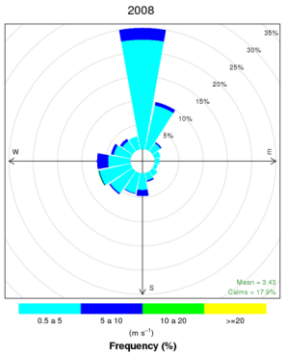
Mesoscale model

WRF-ARW representative year

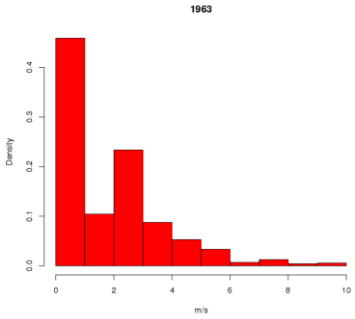
Grant County

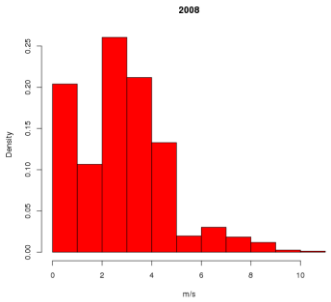


September 1963

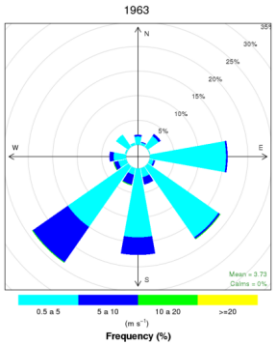


September 2008

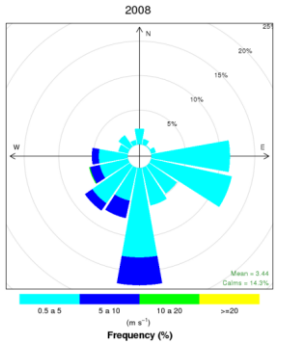




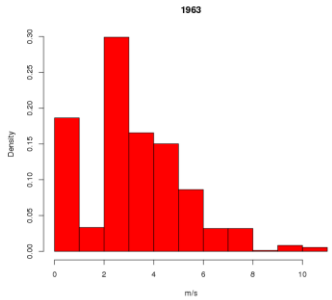
Walla Walla

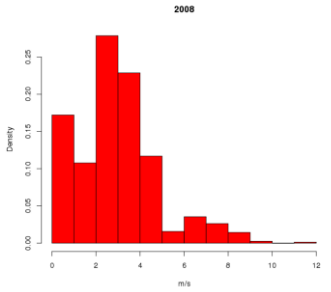


September 1963



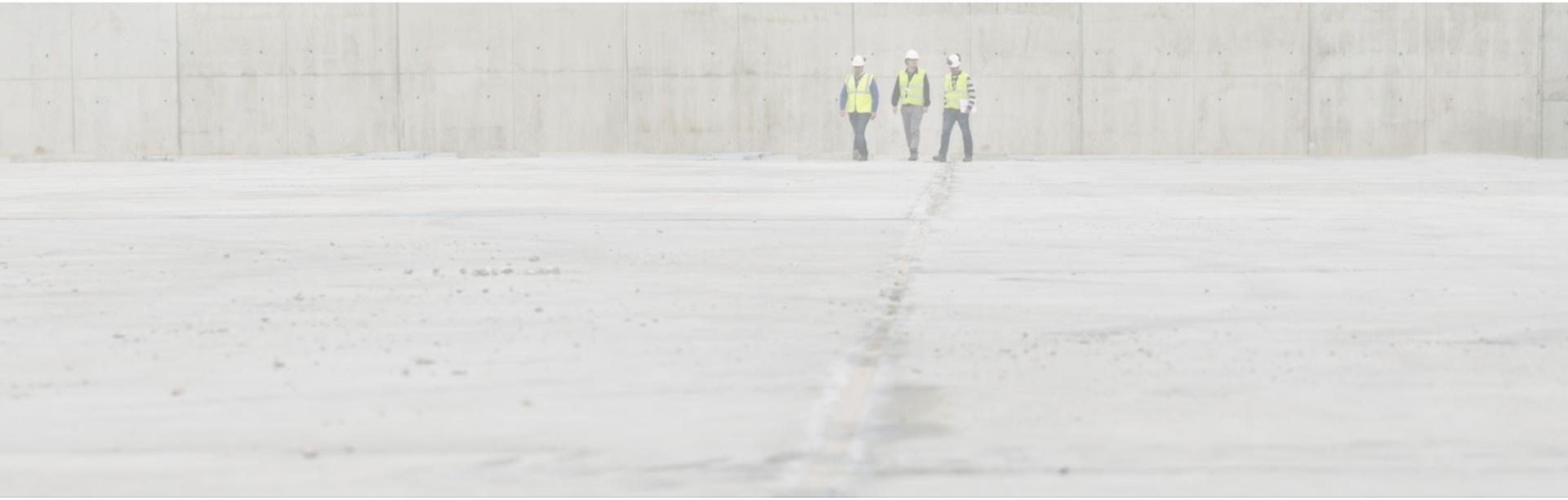
September 2008





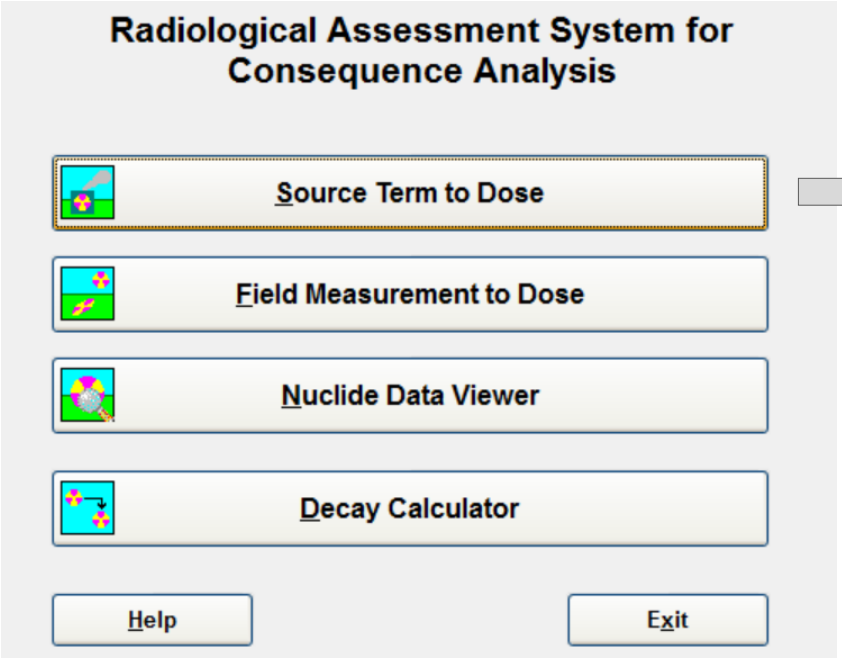
© 2018 IDOM Nuclear Services

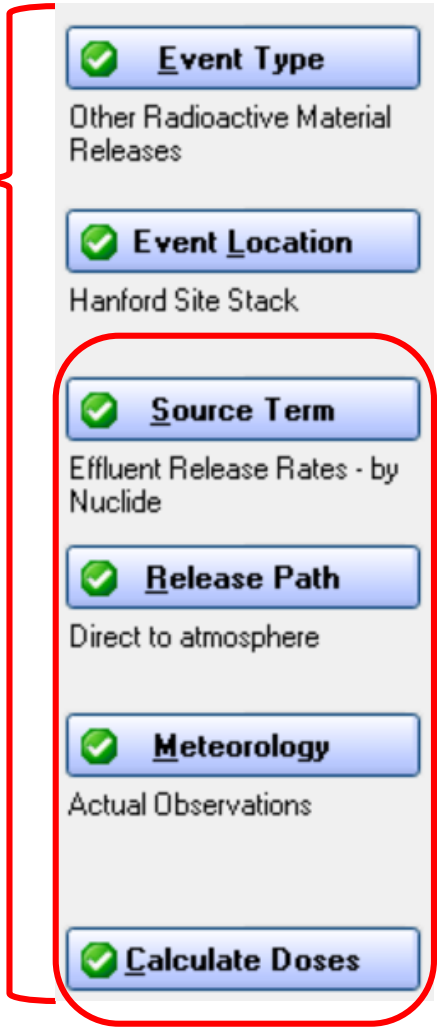
RASCAL simulation

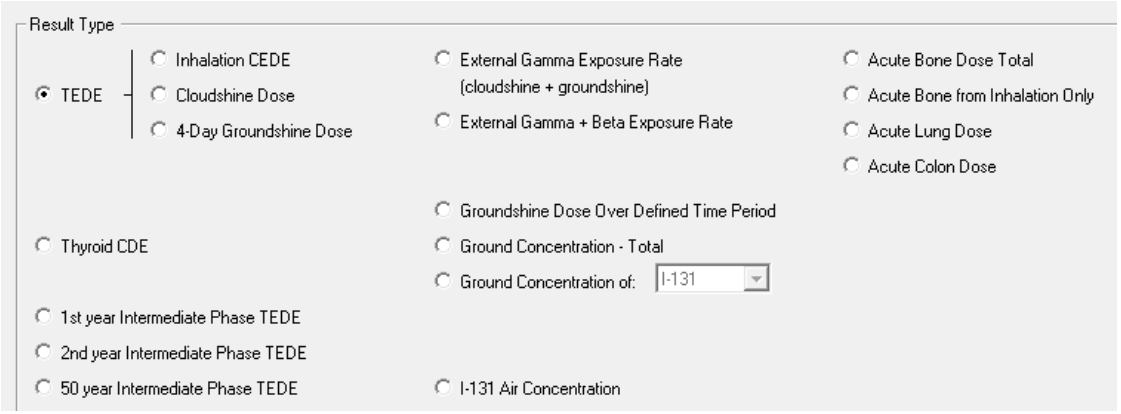


Radiological Assessment System for Consequence AnaLysis (RASCAL)

RASCAL 4.2





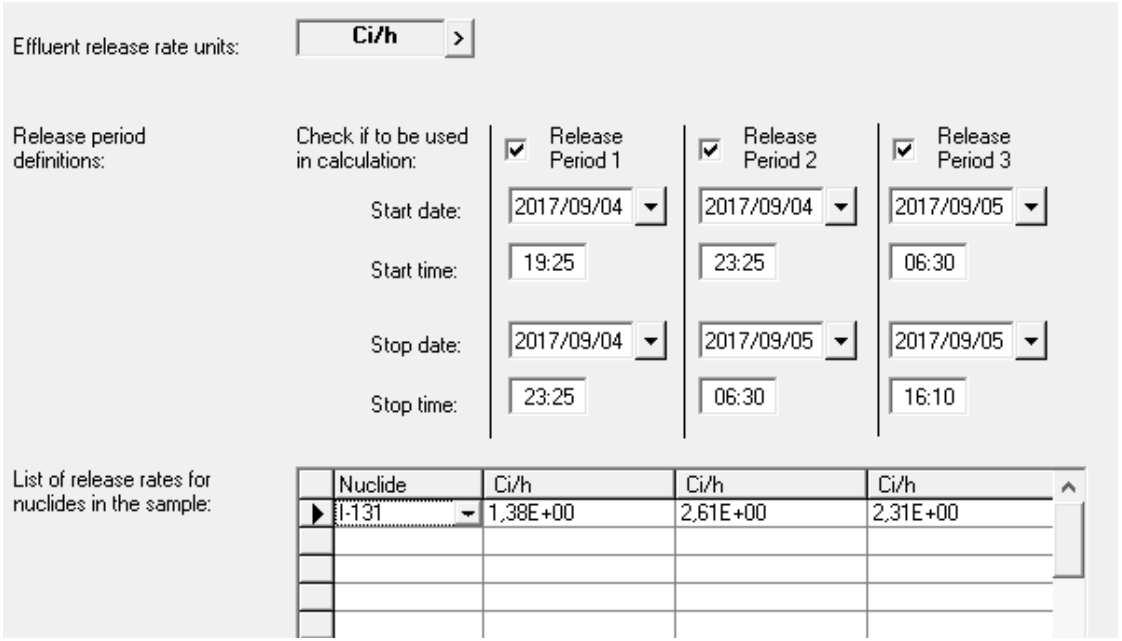


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Radiological Assessment System for Consequence AnaLysis (RASCAL)

RASCAL 4.2

SOURCE TERM MODULE —— Effluent Release Rates by Nuclide



Variable Source Term

But, only three release periods per case

LIMITATION

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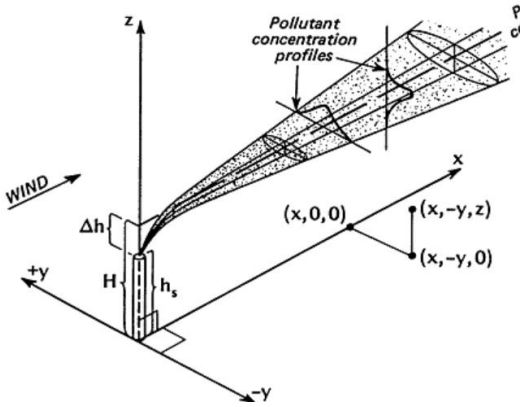
Radiological Assessment System for Consequence AnaLysis (RASCAL)

RASCAL 4.2

ATDM — TADPLUME AND TADPUFF

TADPLUME

Straight-line Gaussian Model



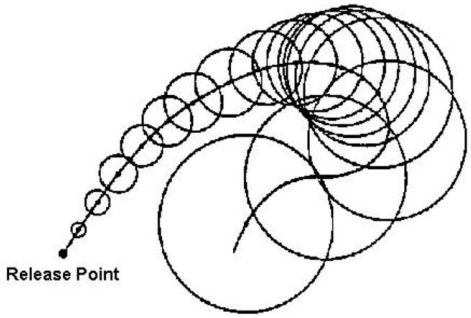
Domain: Close-in calculations

Polar grid with receptor nodes on circles (r = 2 mi, 5 mi, or 10 mi) at 10-degree intervals at eight radial distance

Known inconsistencies with calm winds

TADPUFF

Gaussian Puff Model



Domain: 10-mile, 25-mile, or 50-mile (a side)

→ 41x41 grid

Square cartesian grid with receptor nodes uniformly spaced throughout the domain

→ 0.5 mile in 10-mile

Domains always centered in the release point

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Radiological Assessment System for Consequence AnaLysis (RASCAL)

RASCAL 4.2

METEO DATA — Meteorology Module

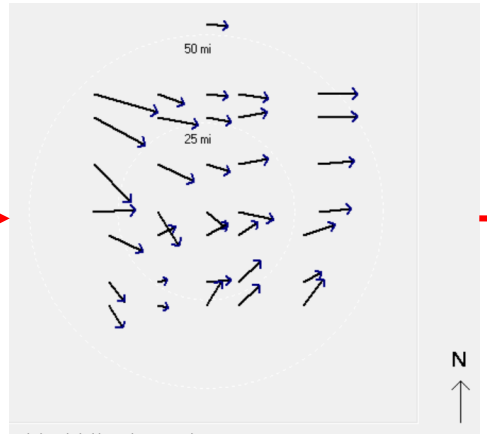
Enter data for: HS01 d04

Station ID	Type	Date	Time (24 h)	Wind Direct from (deg)	Speed (mph)	DT/Dz (deg C / 100,0 m)	Precipitation
HS01	Obs	2017/09/04	00:00	309	8,6	-2,24	No Precip
HS02	Obs	2017/09/04	01:00	308	13,7	-1,72	No Precip
HS03	Obs	2017/09/04	02:00	304	11,6	0,517	No Precip
HS04	Obs	2017/09/04	03:00	300	14,2	0,344	No Precip
HS05	Obs	2017/09/04	04:00	300	12,7	0,517	No Precip
HS06	Obs	2017/09/04	05:00	281	10,2	1,034	No Precip
HS08	Obs	2017/09/04	06:00	286	10,7	0,689	No Precip
HS09	Obs	2017/09/04	07:00	293	11,6	1,206	No Precip
HS10							

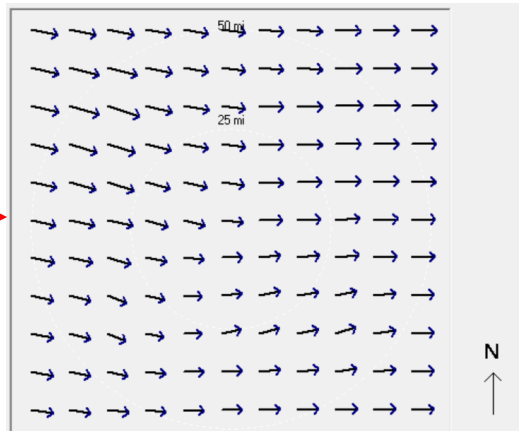
The Meteo module accepts a minimum of 1 station and a maximum of 36 → LIMITATION

The release point shall always be included (and needs Temperature)

The meteo input is supposed to be introduced via user interface → LIMITATION



Variable fields for the 4 domains of interest are generated from the input



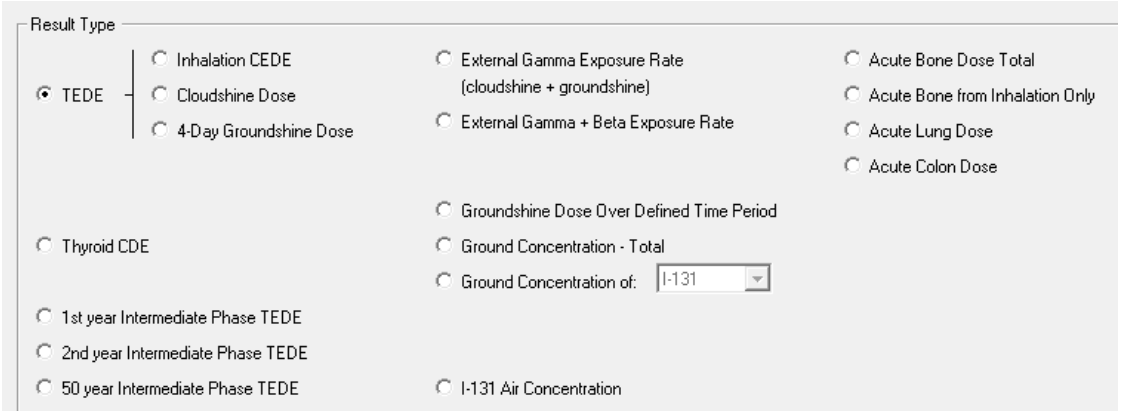
Possible issue: Meteo stations may be within or near the model

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Radiological Assessment System for Consequence AnaLysis (RASCAL)

RASCAL 4.2

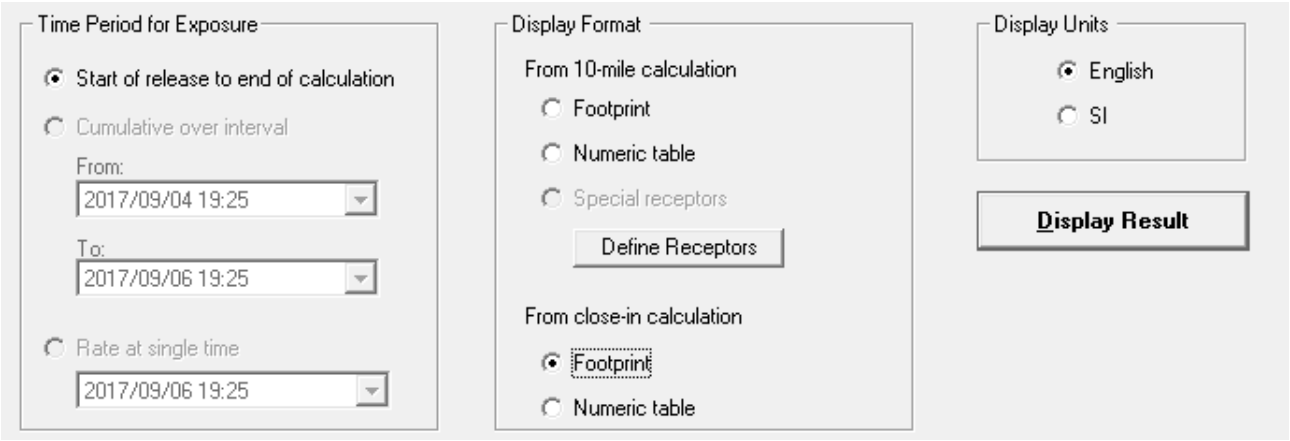
RASCAL OUTPUT — Calculate doses module



RASCAL simulates time periods as long as 48 hours → LIMITATION

Air concentration: RASCAL only presents I-131 → LIMITATION

Ground concentration: all elements



Results: accumulated or single time

No time evolution for a domain node (numerically) → LIMITATION

No time evolution for a receptor → LIMITATION

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Simulation of Hanford Site I-131 release in September 1963

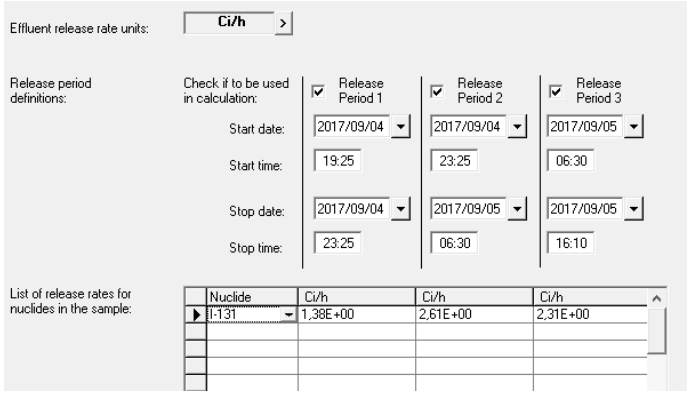
RASCAL 4.2

SOURCE TERM —— Effluent Release Rates by Nuclide

The acute release of I-131 from the 2nd to the 6th of September is simulated with **5 cases** (5x3 = 15 release periods)

Each case simulates 48h and the combination of cases ranges from Sept. the 2nd to Sept. the 8th

From the start of the of the first release period



Release period	Case 1	Case 2	Case 3	Case 4	Case 5
Start (UTC)	09/02 19:25	09/03 10:10	99/04 6:25	09/05 10:10	09/06 10:10
Stop (UTC)	09/02 23:25	09/03 18:55	09/04 15:50	09/05 21:45	09/06 21:25
Rate (Ci/h)	1.38	1.42	0.25	0.04	0.02
Start (UTC)	09/02 23:25	09/03 18:55	09/04 15:50	09/05 21:45	09/06 21:25
Stop (UTC)	09/03 6:30	09/03 22:10	09/04 22:00	09/06 7:30	09/07 10:00
Rate (Ci/h)	2.61	0.73	0.21	0.02	0.01
Start (UTC)	09/03 6:30	09/03 22:10	09/04 22:00	09/06 7:30	09/07 10:00
Stop (UTC)	09/03 10:10	09/04 6:25	09/05 10:10	09/06 10:10	09/07 23:59
Rate (Ci/h)	2.31	0.64	0.06	0.02	0.02

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Simulation of Hanford Site I-131 release in September 1963

RASCAL 4.2

METEO DATA — Meteorology Module

Meteo data is introduced for 36 stations thanks to the modification of .OBS files inside .MDS

```
577
 9 42017 0 0    732 -999.91     09O  3098.5752-2.242   100103
 9 42017 01572.752 -999.91     09I308.69.8632-2.112   100103
 9 42017 030 72.52 -999.91     09I308.311.152-1.982   100103
 9 42017 04572.252 -999.91     09I308.112.442-1.852   100103
 9 42017 1 0    722 -999.91     09O  30813.732-1.722   100103
 9 42017 11571.122 -999.91     09I307.113.192-1.162   100103
 9 42017 13070.252 -999.91     09I306.112.662-0.602   100103
 9 42017 14569.372 -999.91     09I305.112.132-4.222   100103
 9 42017 2 0 68.52 -999.91     09O  30411.6120.5172   100103
 9 42017 21567.822 -999.91     09I302.812.2520.4732   100103
 9 42017 23067.152 -999.91     09I301.712.9020.4302   100103
 9 42017 24566.472 -999.91     09I300.813.5620.3872   100103
 9 42017 3 0 65.82 -999.91     09O  30014.2220.3442   100103
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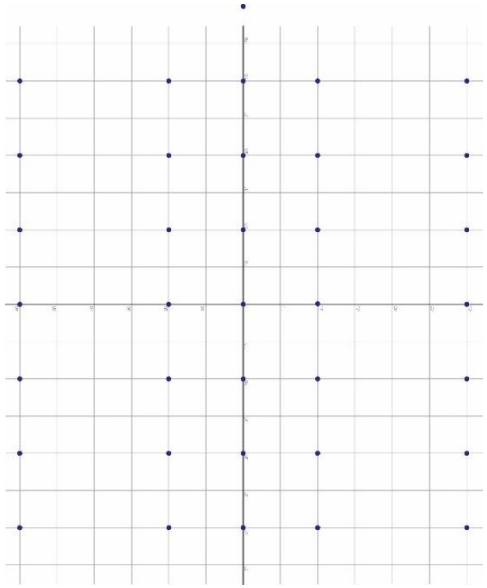
Meteo data is introduced for the 09/02 00:00 – 09/08 00:00 period

Hourly data from d04 domain – RASCAL interpolates

RASCAL couldn't handle a full month of data. Hence, data for the shortest reasonable time period for the case of study was introduced and accepted

Enter data for: HS01 d04

Station ID	Type	Date	Time (24 h)	Wind Direct from (deg)	Speed (mph)	DT/Dz (deg C / 100,0 m)	Precipitation
HS01	Obs	2017/09/04	00:00	309	8,6	-2,24	No Precip
HS02	Obs	2017/09/04	01:00	308	13,7	-1,72	No Precip
HS03	Obs	2017/09/04	02:00	304	11,6	0,517	No Precip
HS04	Obs	2017/09/04	03:00	300	14,2	0,344	No Precip
HS05	Obs	2017/09/04	04:00	300	12,7	0,517	No Precip
HS06	Obs	2017/09/04	05:00	281	10,2	1,034	No Precip
HS08	Obs	2017/09/04	06:00	286	10,7	0,689	No Precip
HS09	Obs	2017/09/04	07:00	293	11,6	1,206	No Precip
HS10							



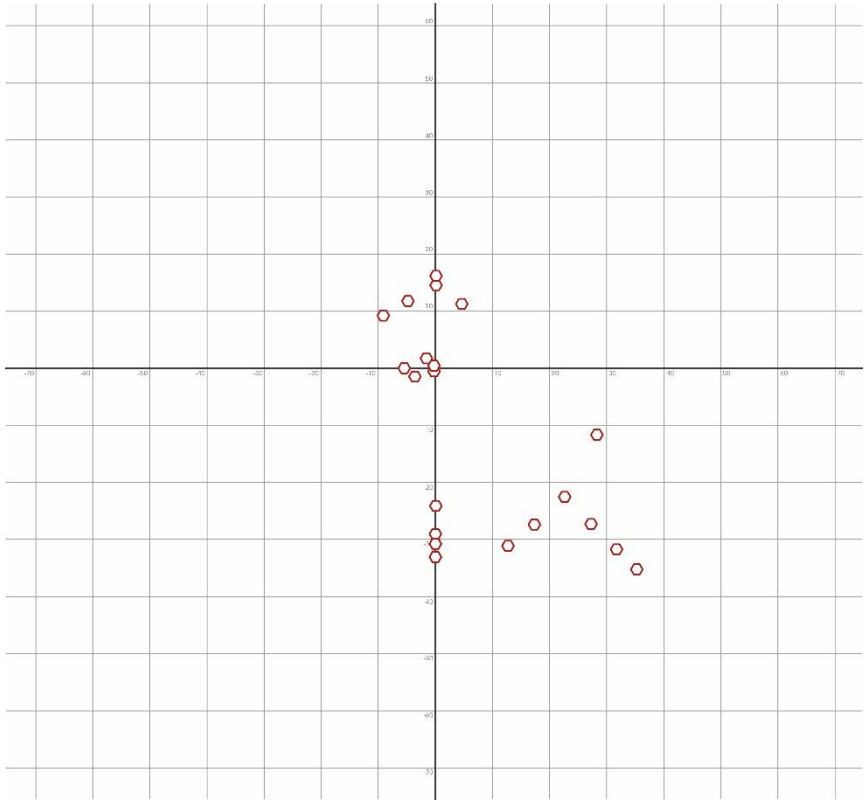
RASCAL 50-mi domain

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Simulation of Hanford Site I-131 release in September 1963

RASCAL OUTPUT

Results obtained from analysis of nearby domain nodes and RASCAL receptors



RASCAL 4.2

Same results for the alternative domain

ID	Domain	Measure (pCi/m3)	Peak time (s)	Simulation (pCi/m3)
1	10 mi	0,85	-	0,0
2	10 mi	0,7	-	0,0
3	10 mi	0,35	-	0,0
4	25 mi	0,28	-	0,0
5	10 mi	0,32	-	0,0
6	Polar	52,6	37800	9200,0
7	Polar	2,3	2700	196,0
8	Polar	72,7	37800	20700,0
9	Polar	4,7	37800	482,0
10	Polar	3	4500	323,0
11	25 mi	0,1	33300	287,0
12	25 mi	0,08	127800	99,5
13	25 mi	0,1	127800	99,5
14	25 mi	0,14	27000	18,4
15	25 mi	0,15	64800	435,0
10	25 mi	0,24	31500	14,6
17	25 mi	0,14	28800	5,5
18	25 mi	0,14	103500	4,0
19	25 mi	0,14	103500	3,2
20	25 mi	0,14	34200	201,0
21	25 mi	0,16	36000	115,0
22	25 mi	0,08	127800	99,5
23	25 mi	0,1	128700	79,8

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Simulation of Hanford Site I-131 release in September 1963

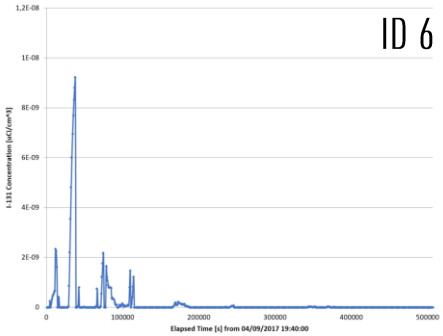
RASCAL 4.2

Same results for the alternative domain

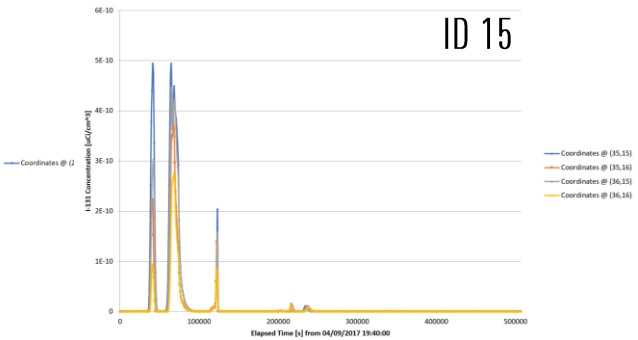
RASCAL OUTPUT

Results obtained from analysis of nearby domain nodes and RASCAL receptors

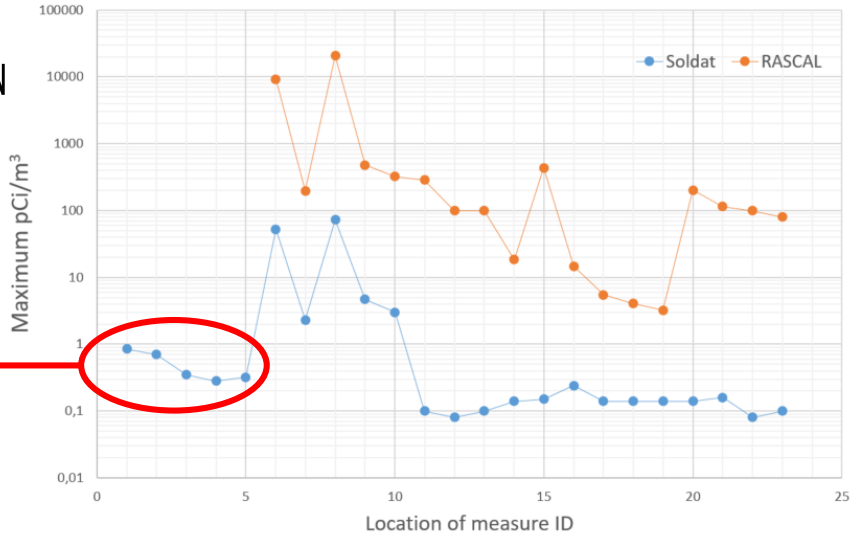
ID 6



ID 15



OVERESTIMATION



North of the release

ID	Domain	Measure (pCi/m3)	Peak time (s)	Simulation (pCi/m3)
1	10 mi	0,85	-	0,0
2	10 mi	0,7	-	0,0
3	10 mi	0,35	-	0,0
4	25 mi	0,28	-	0,0
5	10 mi	0,32	-	0,0
6	Polar	52,6	37800	9200,0
7	Polar	2,3	2700	196,0
8	Polar	72,7	37800	20700,0
9	Polar	4,7	37800	482,0
10	Polar	3	4500	323,0
11	25 mi	0,1	33300	287,0
12	25 mi	0,08	127800	99,5
13	25 mi	0,1	127800	99,5
14	25 mi	0,14	27000	18,4
15	25 mi	0,15	64800	435,0
10	25 mi	0,24	31500	14,6
17	25 mi	0,14	28800	5,5
18	25 mi	0,14	103500	4,0
19	25 mi	0,14	103500	3,2
20	25 mi	0,14	34200	201,0
21	25 mi	0,16	36000	115,0
22	25 mi	0,08	127800	99,5
23	25 mi	0,1	128700	79,8

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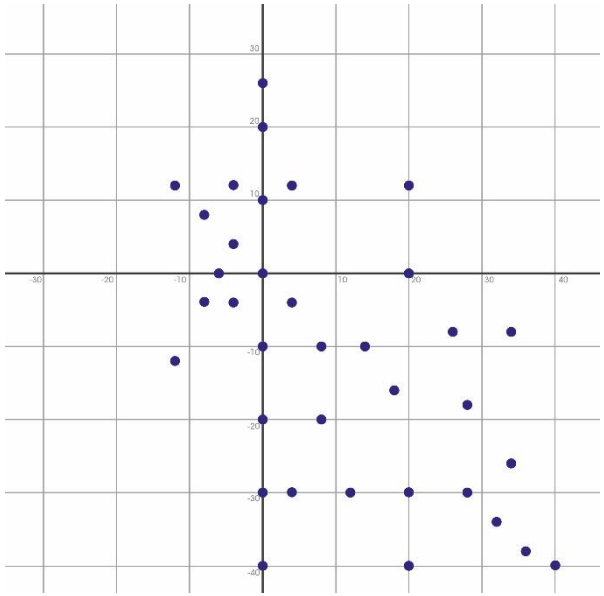
Simulation of Hanford Site I-131 release in September 1963

RASCAL 4.2

METEO DATA

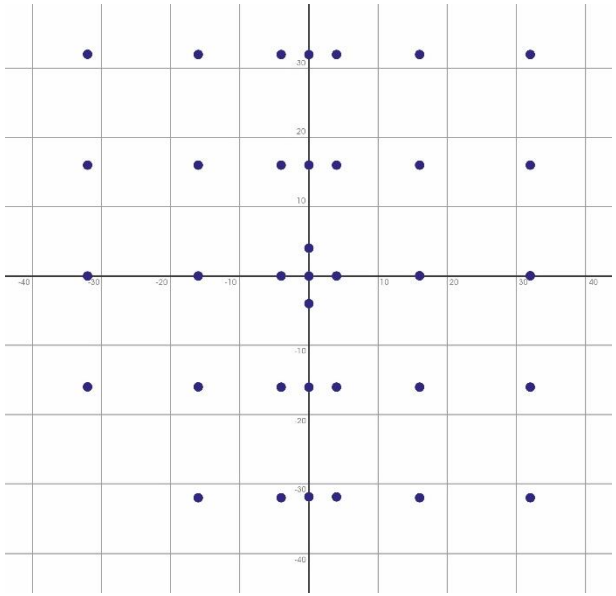
To analyze how the distribution of Meteo stations affects the results

Alternative Meteo 1 (AM1)



Meteo stations located near the majority of measure points

Alternative Meteo 2 (AM2)



Meteo stations uniformly distributed within the 20 mi domain

Only one meteo station at the release point (1STA)

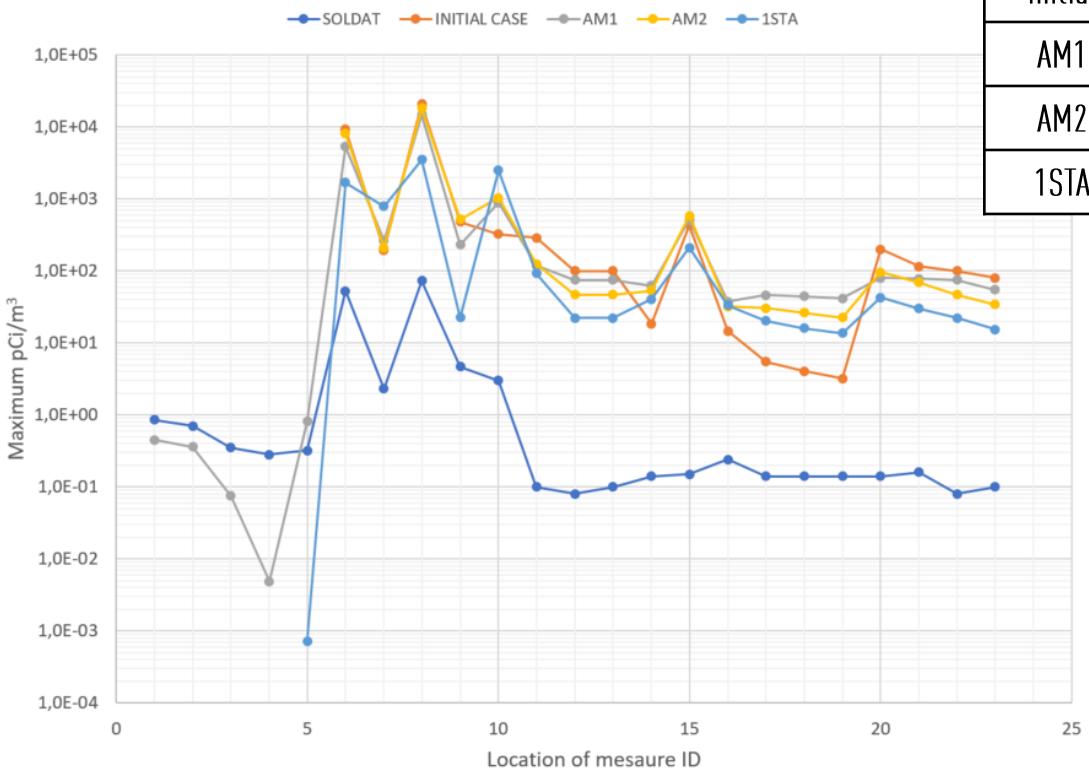
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RASCAL 4.2

SENSITIVITY RESULTS

1STA is not bounding!



Case	RMSE
Initial	174.2
AM1	54.7
AM2	34.4
1STA	125.1

RASCAL results are dependent on the location of meteo stations

↓

UNCERTAINTY (model)

Differences between 1 STA and 36 STA cases are not highly noticeable

Sensitivity to domain has also been addressed for IDs 1 to 5 showing that results are also domain dependent

Not shown in graphic

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RASCAL 4.2

CONCLUSIONS

RASCAL results highly overestimate the field measurements

RASCAL results show a similar trend to that of the field measurements

RASCAL results substantially depend on where the meteo stations are located (thus, wind fields)

RASCAL results also depend on the quantity of meteo stations used (resolution)

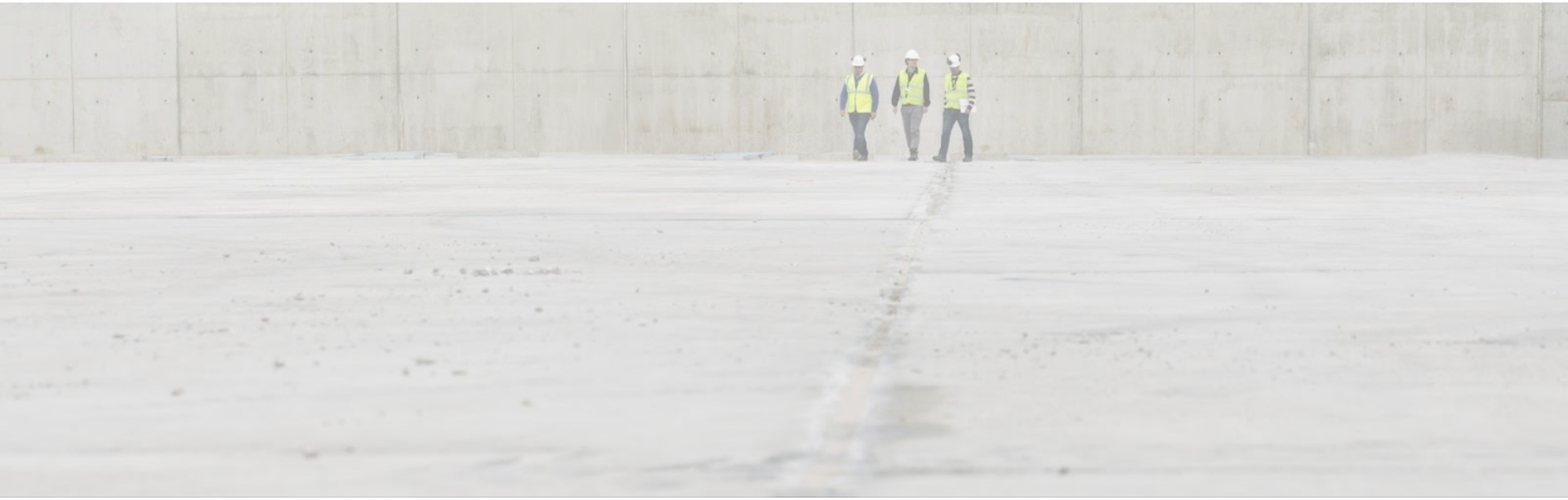
RASCAL results for 1STA are not bounding

RASCAL results are also sensitive to the domain of calculation used

RASCAL results from case AM2 are the best fit according to RMSE

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HYSPLIT simulation



Simulation of Hanford Site I-131 release in September 1963

SOURCE TERM

Obtain results with maximum number of meteo scenarios

3 source term scenarios simulated for the 2nd to the 30th day of 1980 to 2010 September (29*31 = 899 simulations)

Each simulation lasts 24 hours → Maximum is likely to be reached at the first 24 hours

```
Archivo  Editar  Ver  Buscar  Terminal  Ayuda
98 09 01 19 25
1
46.5487417 -119.519042 60
24
0
10000.0
2
/data3/meteosim/handforsite/runs/handford_site-1km/1998090112/d04/
WRFDATA.ARL
/data3/meteosim/handforsite/runs/handford_site-1km/1998083112/d04/
WRFDATA.ARL
1
I131
96635294117.6471
11.0833
98 09 01 19 25
1
46.5487417 -119.519042
0.012 0.012
1.5 1.5
./
cdump
1
10
00 00 00 00 00
00 00 00 00 00
00 1 00
1
0.0 0.0 0.0
0.01 0.0 0.0 0.0 0.0
3.00 0.0 0.0
8.04
0.0
~
```

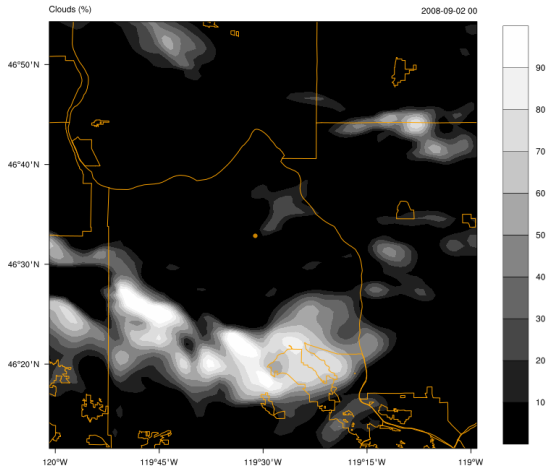
Maximum rate | Avg. rate (09/02 – 09/30) | Same as RASCAL's case 1

Release period	Scenario 1	Scenario 2	Scenario 3
Start (UTC)	09/02 12:25	09/03 0:00	09/02 19:25
Stop (UTC)	09/02 23:30	09/03 24:00	09/02 23:25
Rate (Ci/h)	2.61	0.49	1.38
Start (UTC)			09/02 23:25
Stop (UTC)			09/03 6:30
Rate (Ci/h)			2.61
Start (UTC)			09/03 6:30
Stop (UTC)			09/03 10:10
Rate (Ci/h)			2.31

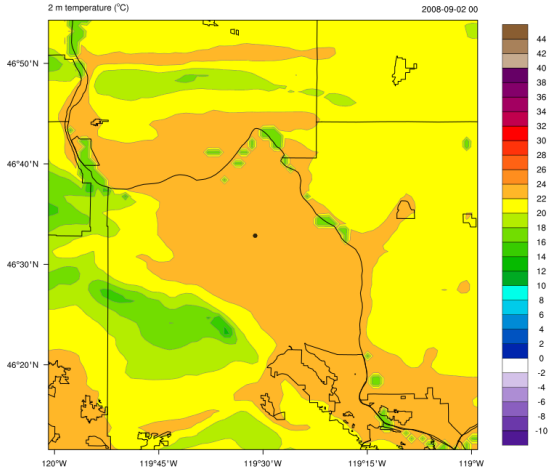
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Simulation of Hanford Site I-131 release in September 1963

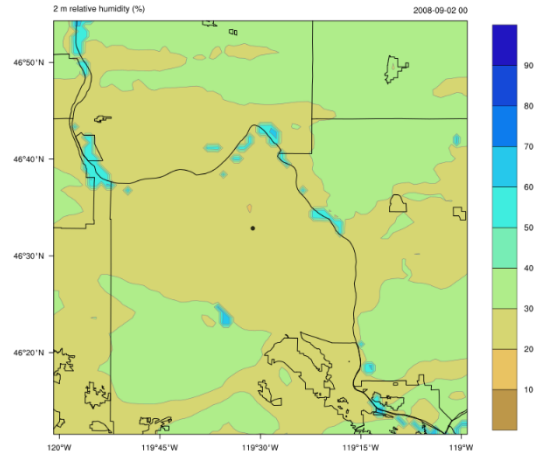
METEO DATA —— d04 model from WRF



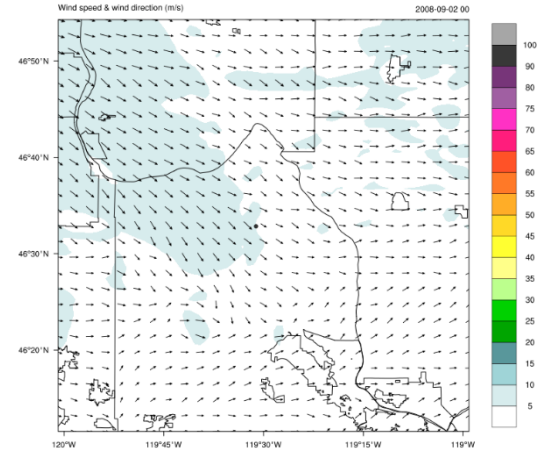
Clouds



Temperature



Relative humidity



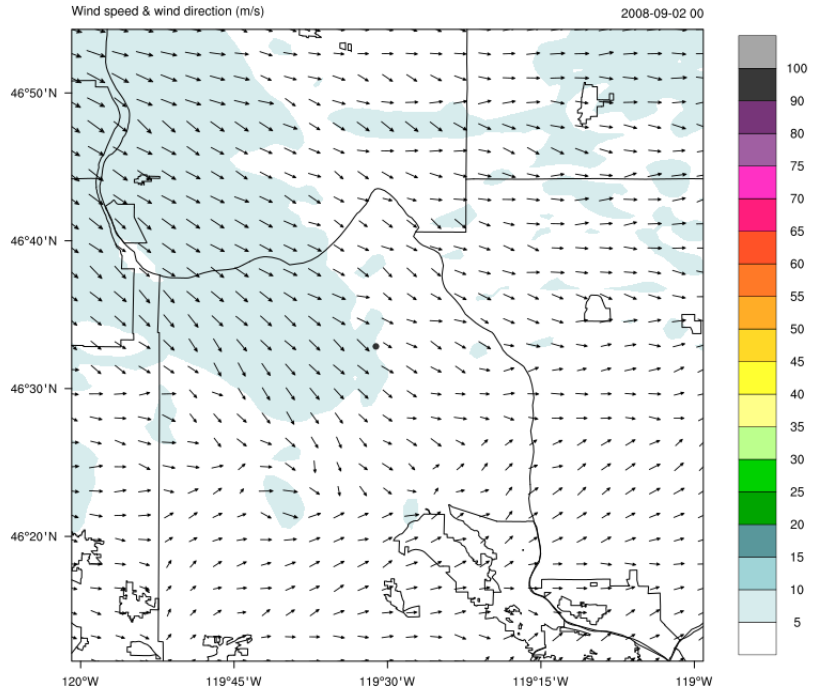
Winds

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Simulation of Hanford Site I-131 release in September 1963

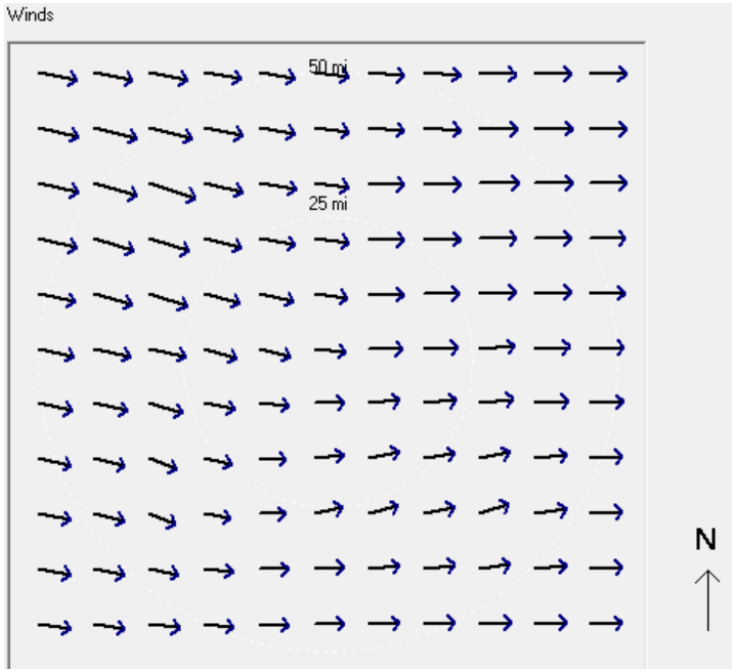
METEO DATA —— d04 model from WRF

Winds from 2008/09/02 00:00



Input HYSPLIT

!!



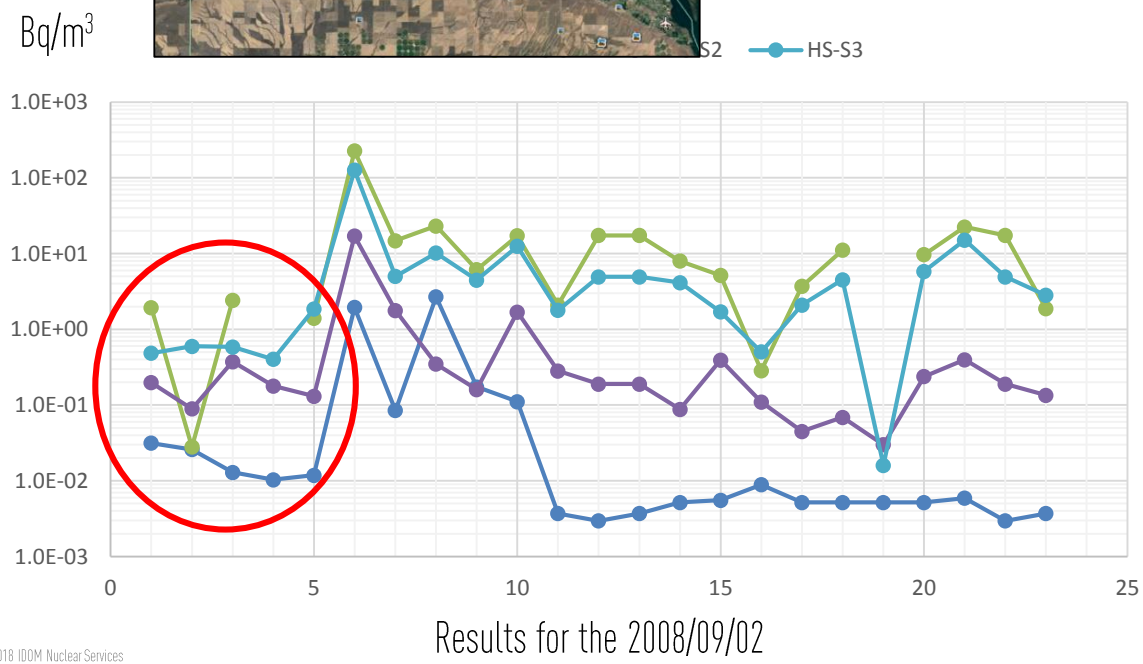
Input RASCAL

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Simulation of Hanford Site I-131 release in September 1963



Results for the 2008/09/02

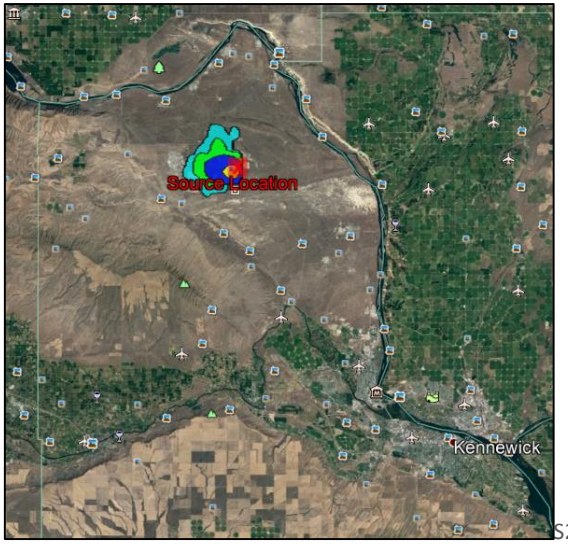


Results for the 2008/09/02

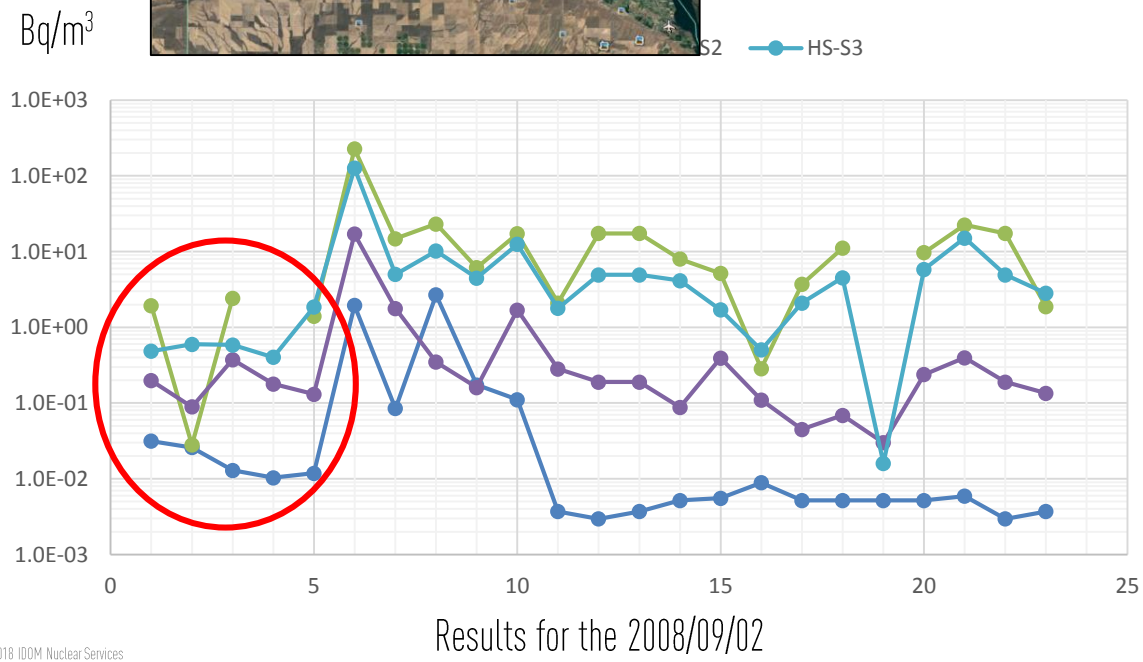
ID	Scenario 1 (Bq/m3)	Scenario 2 (Bq/m3)	Scenario 3 (Bq/m3)
1	1,94	0,20	0,49
2	0,03	0,09	0,60
3	2,43	0,38	0,59
4	0,00	0,18	0,40
5	1,40	0,13	1,86
6	226,26	17,01	126,62
7	14,80	1,78	5,01
8	23,16	0,35	10,17
9	6,15	0,16	4,48
10	17,22	1,69	12,51
11	2,09	0,28	1,79
12	17,42	0,19	4,94
13	17,42	0,19	4,94
14	7,98	0,09	4,14
15	5,15	0,39	1,70
10	0,29	0,11	0,51
17	3,70	0,05	2,10
18	11,10	0,07	4,52
19	0,00	0,03	0,02
20	9,69	0,24	5,82
21	22,45	0,40	15,11
22	17,42	0,19	4,94
23	1,87	0,14	2,82

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Simulation of Hanford Site I-131 release in September 1963



Results for the 2008/09/02

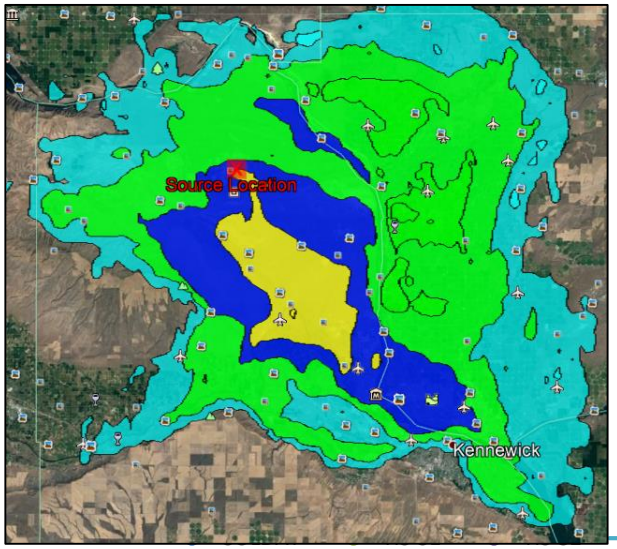


Results for the 2008/09/02

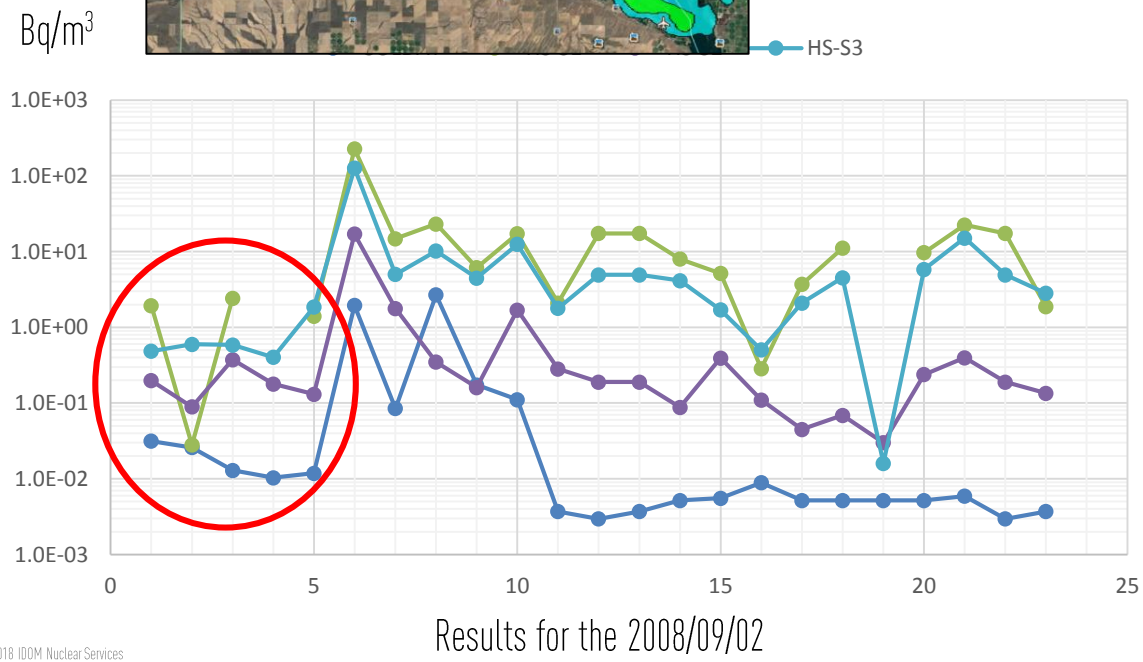
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Simulation of Hanford Site I-131 release in September 1963



Results for the 2008/09/02

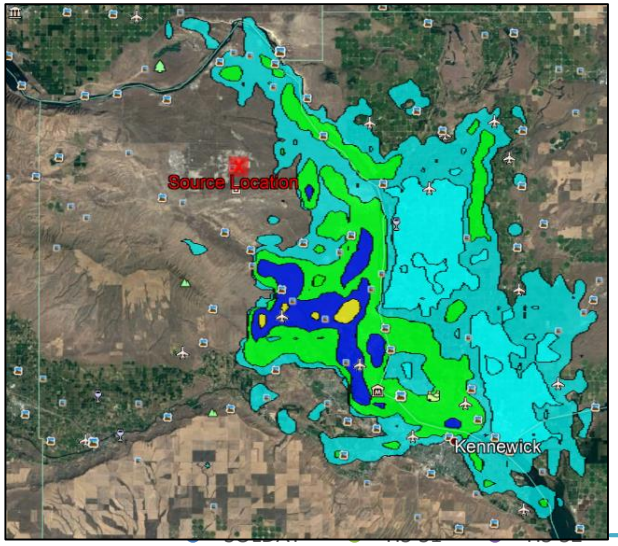


Results for the 2008/09/02

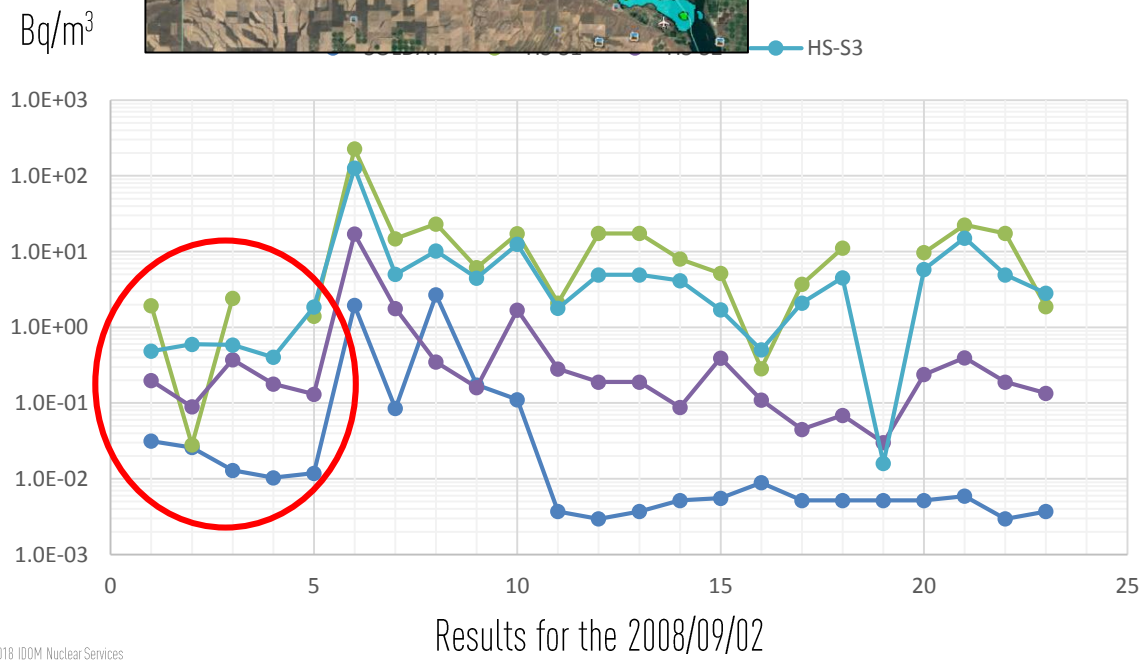
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Simulation of Hanford Site I-131 release in September 1963



Results for the 2008/09/02

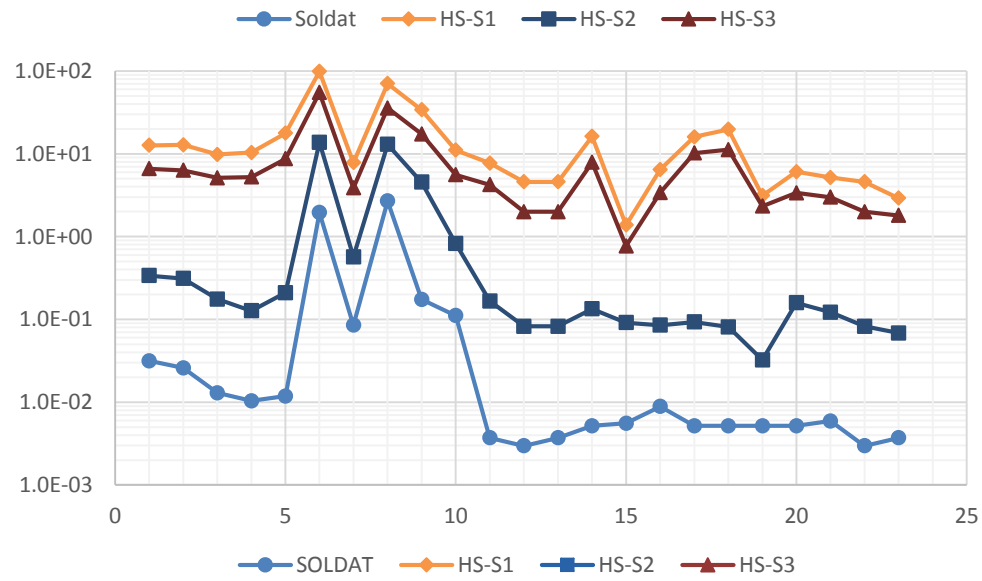


Results for the 2008/09/02

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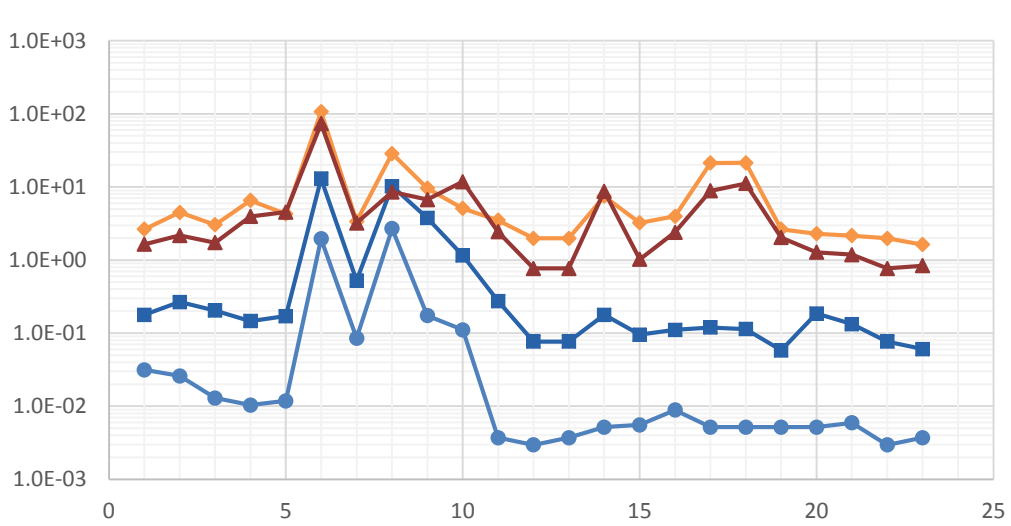
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Average of maximums for 1980-2010

Scenario		RMSE
1	20080902	45,6
	Average	30,4
	Average 2008	11,5
2	20080902	12,7
	Average	2,9
	Average 2008	0,6
3	20080902	33,4
	Average	16,8
	Average 2008	7,6



Average of maximums for 2008

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Simulation of Hanford Site I-131 release in September 1963

CONCLUSIONS

HYSPLIT results overestimate the field measurements, even with a lower source term

Scenario 2 (lower source term) is the best fit

→ Is source term overestimated?

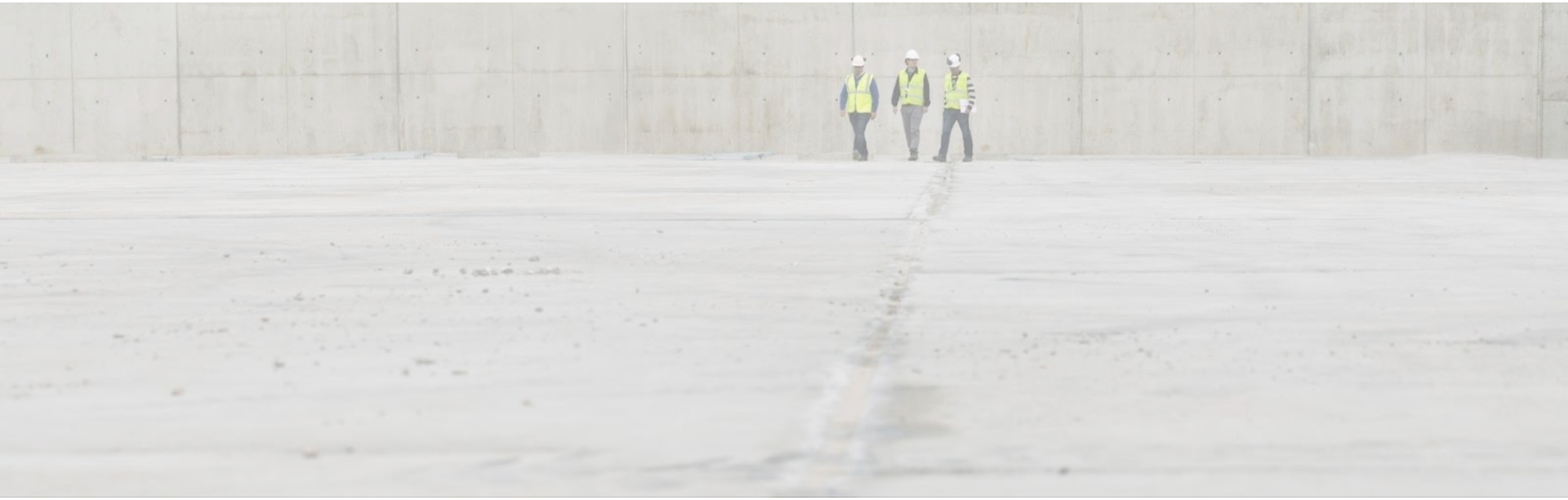
AVG 2008 RMSE is lower than AVG RMSE thus confirming 2008 as a representative year

AVGs RMSE are much lower than one day RMSE. Hence, it is not convenient to work with only one day of data

HYSPLIT results show a similar trend to that of the field measurements even though the simulation duration is only 24 hours

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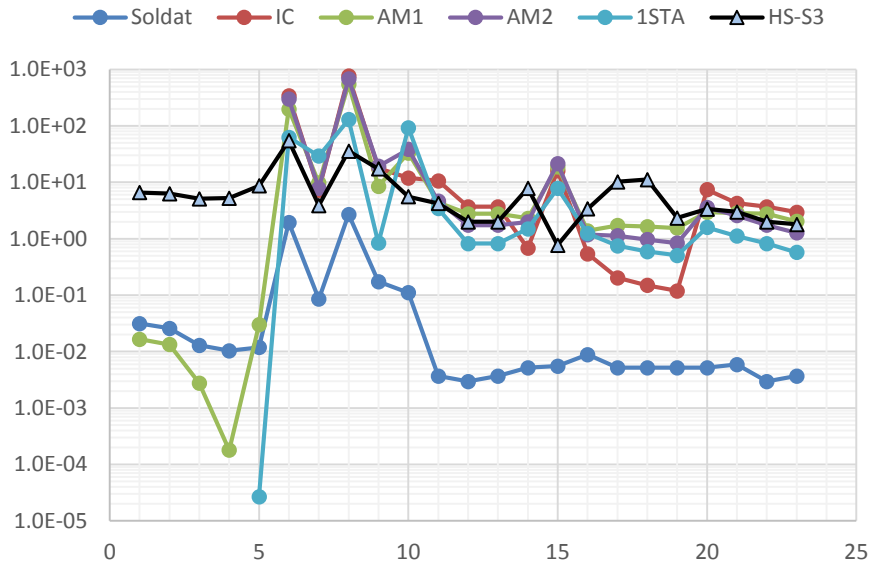
BENCHMARK



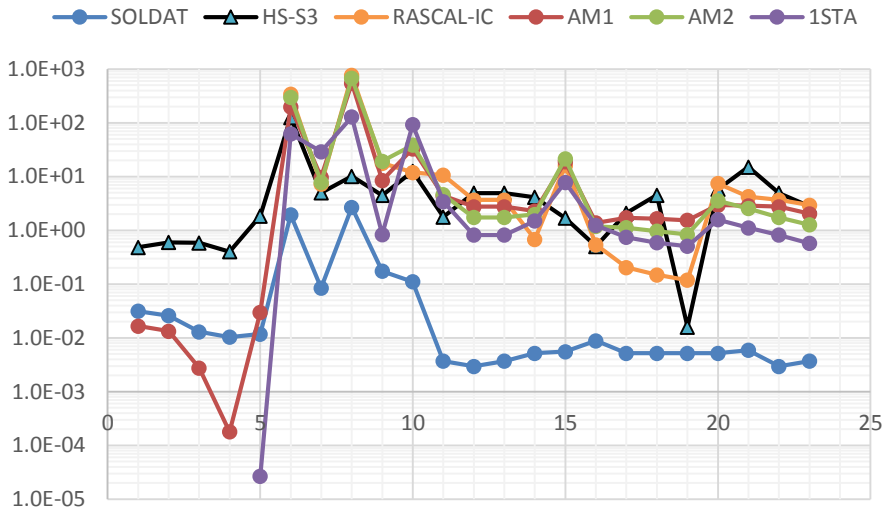
Simulation of Hanford Site I-131 release in September 1963

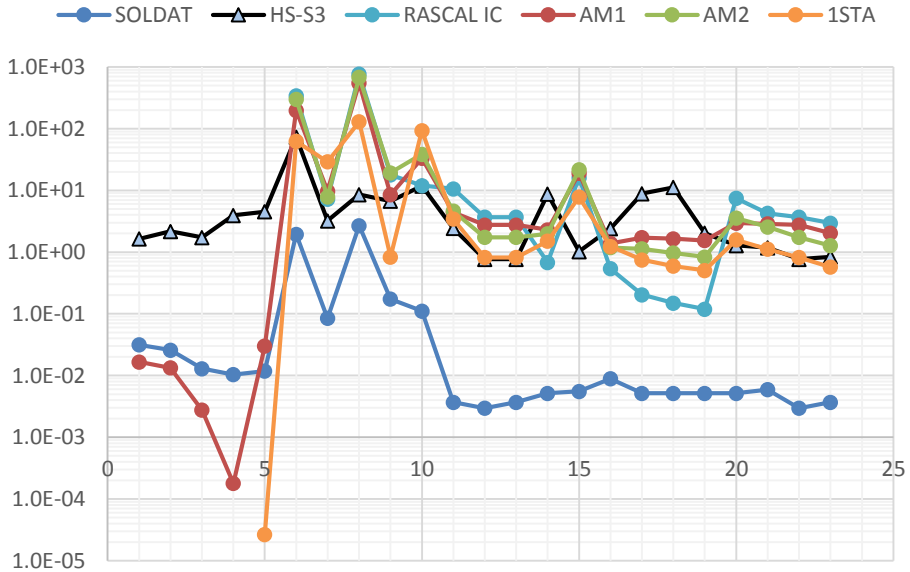
2008/09/02

RASCAL CASES vs HYPSLIT Scenario 3 (Bq/m³)



AVG TOTAL





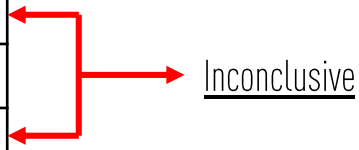
AVG 2008

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Simulation of Hanford Site I-131 release in September 1963

RASCAL CASES vs HYPSLIT Scenario 3 (Bq/m^3)

Scenario		RMSE
RASCAL	INITIAL CASE	174.2
	AM1	54.7
	AM2	34.4
	1STA	125.1
HYSPLIT 3	20080902	33.4
	Average	16.8
	Average 2008	**7.6**



Inconclusive

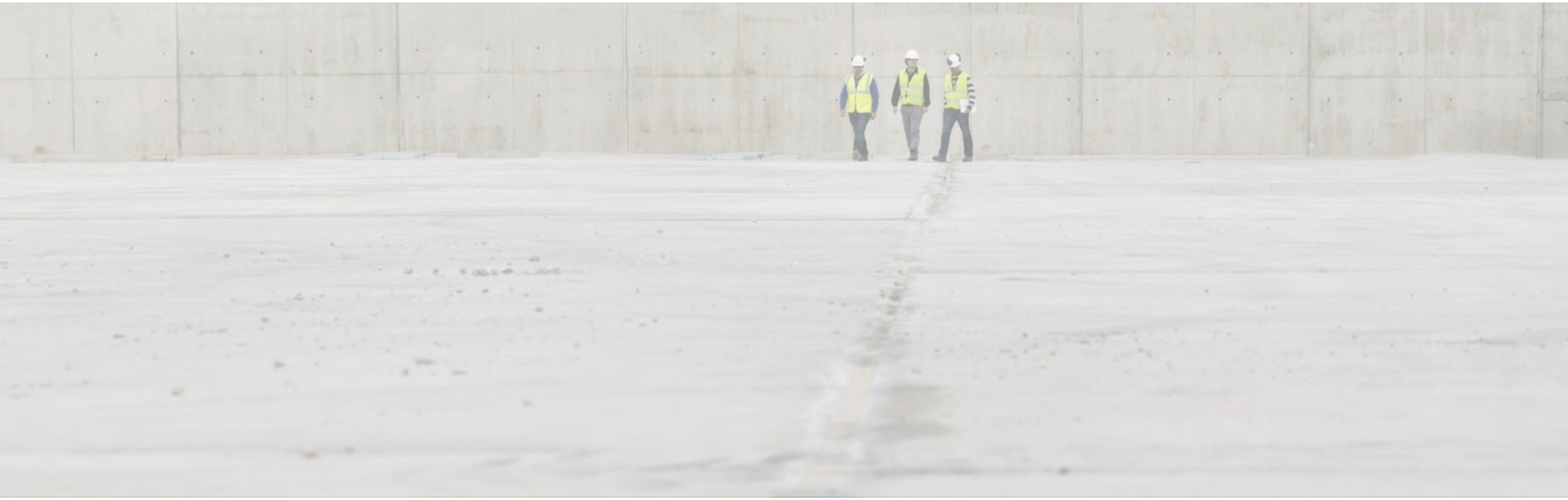
Visually, RASCAL results and HYSPLIT results are similar, but

HYSPLIT 3 20080902 RMSE is better than all RASCAL cases, specially when compared with INITIAL CASE, AM1, and 1STA

According to RMSE, HYSPLIT results are a better estimation of the measured values (based on average values)

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CONCLUSIONS



Simulation of Hanford Site I-131 release in September 1963

RASCAL results highly overestimate the field measurements

RASCAL results show a similar trend to that of the field measurements

RASCAL results substantially depend on where the meteo stations are located (thus, wind fields) and the quantity of stations

HYSPLIT results overestimate the field measurements

HYSPLIT results show a similar trend to that of the field measurements even though the simulation lasts 24 hours

AVGs RMSE are much lower than one day RMSE. Hence, it is not convenient to work with only one day of data

RASCAL results are likely to be worse than HYPSLIT's (meteo optimization)

According to RMSE, HYSPLIT results are a better estimation of the measured values (based on average values)

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Simulation of Hanford Site I-131 release in September 1963

A better benchmark should be performed where both RASCAL and HYSPLIT analyses are the same:

Analyze which is the September day or group of days that best fit 1963 meteo data

or

Run RASCAL simulations as it has been done for HYSPLIT

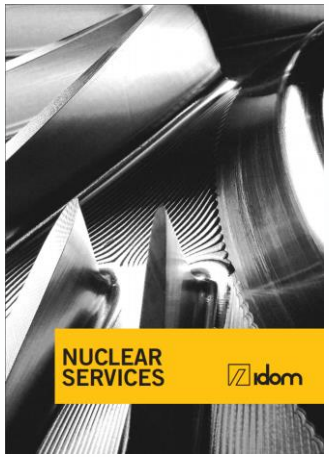
Analyze how Iodine treatment may affect the results

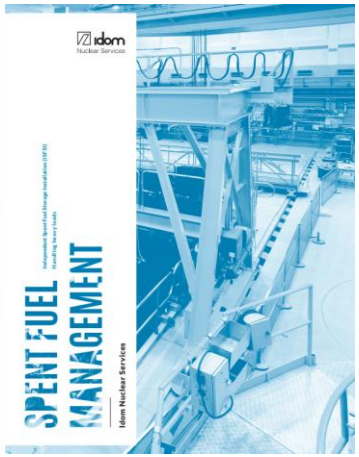
Include ground concentration

Introduce MACCS2 into the BENCHMARK

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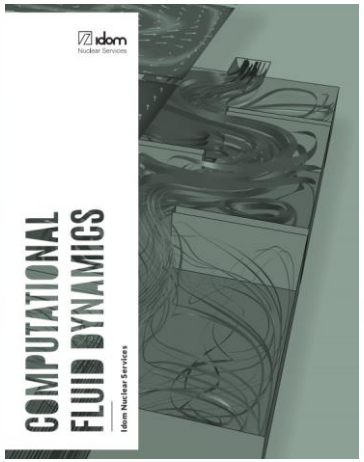
Thank you











More info at idom.com