Evaluation of dispersion models DIPCOT and RIMPUFF used in Decision Support Systems for nuclear and radiological emergency response

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Introduction

The atmospheric dispersion models DIPCOT and RIMPUFF are incorporated for operational use in the Decision Support System (DSS) RODOS for nuclear emergencies. RIMPUFF is also used in the DSS ARGOS.

In this paper an evaluation exercise of DIPCOT and RIMPUFF is presented through comparisons of model-predicted with measured gamma radiation dose rates in air.

Models Description

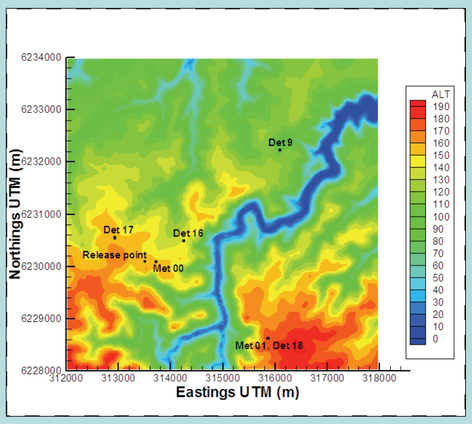
DIPCOT and RIMPUFF are Lagrangian puff models. Concentration of nuclides in air and gamma dose rates are calculated at a particular location and time by summing the contribution of all neighbouring puffs. The differences between the two models are located in the use and pre-processing of meteorological fields, especially the wind velocity field, in the movement of the puffs and in the parameterization of turbulence.

Experimental Data Base

- Dispersion of ^{41}Ar released operationally from the HIFAR Research Reactor (ANSTO, Sydney, Australia)
- 16 different cases covering winter and summer periods of the years 2002 and 2003 and all the atmospheric stability conditions
- Experimental data: ^{41}Ar stack emission rate, meteorological data from 2 stations and gamma dose rates from 4 monitoring stations located in a radius of 5 km around the reactor (15-min time intervals)

The computational domain with terrain elevation contours, the ^{41}Ar release location, the meteorological stations (Met00, Met01) and the gamma dose rate detectors (Det9, Det16, Det17, Det18)

The terrain is moderately complex with hills and valleys and varying land cover: urban (south-east part), suburban (central part), woods (along the river) and low vegetation (north and south-west part) areas

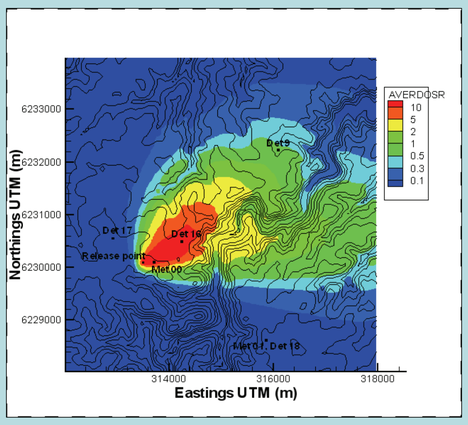


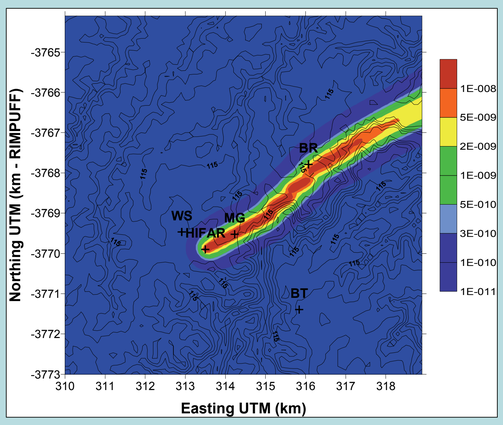
Models Evaluation and Intercomparison

The models evaluation has been performed through comparisons of calculated vs. measured gamma radiation dose rates from the 4 monitoring stations located in a radius of 5 km around the reactor:

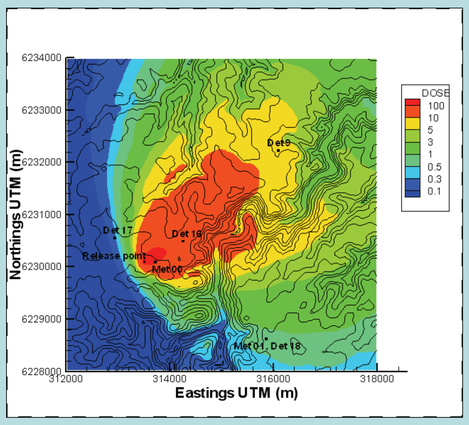
- time-history plots
- statistical analyses through BOOT software

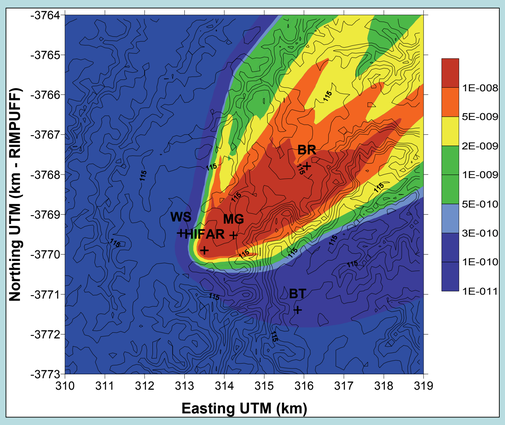
Contour plots of gamma dose rates and accumulated doses have been used for the model intercomparison.



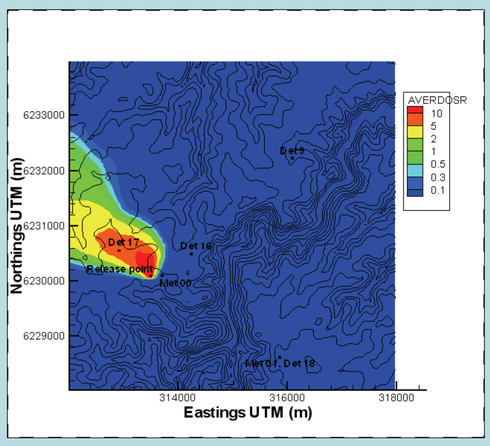


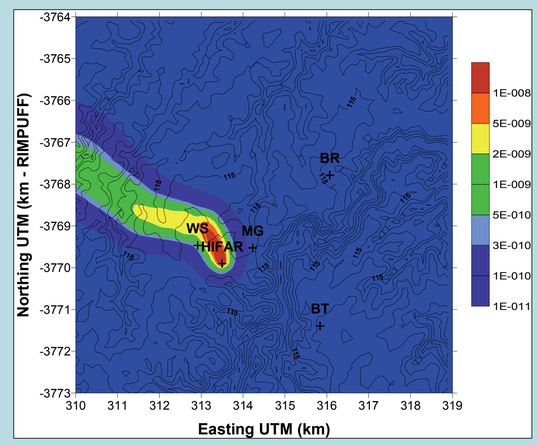
Contour plot of calculated gamma dose rate overlaid on terrain contours for the case of 11/6/2003 at 01:15 EST; left DIPCOT (nGy/hr), right RIMPUFF (Gy/hr) - winter case with stable conditions during night time that later turned to neutral and finally unstable the next morning



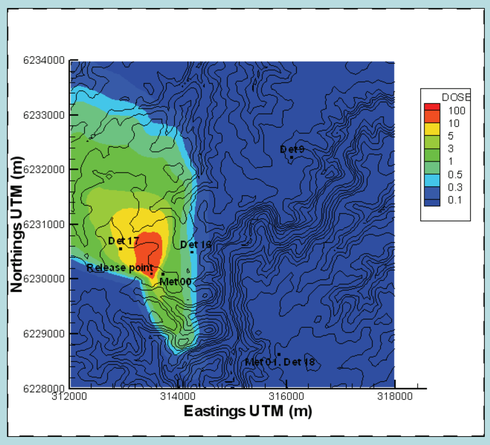


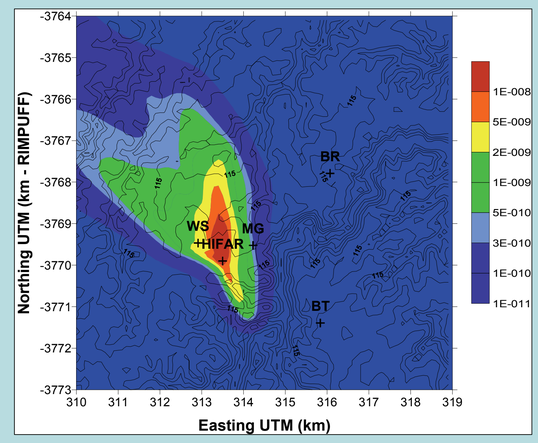
Contour plot of calculated dose overlaid on terrain contours for the time interval 10/6/2003, 22:30 to 11/6/2003 10:15 EST; left DIPCOT (nGy), right RIMPUFF (Gy)



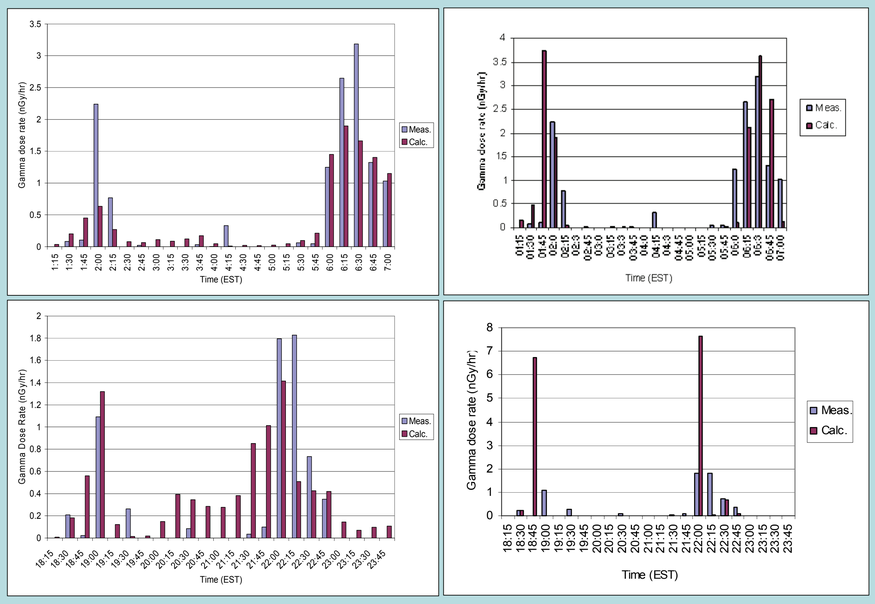


Contour plot of calculated gamma dose rate overlaid on terrain contours for the case of 26/6/2003 at 23:00 EST; left DIPCOT (nGy/hr), right RIMPUFF (Gy/hr) - winter case with neutral conditions





Contour plot of calculated dose overlaid on terrain contours for the time interval 26/6/2003, 22:30 to 27/6/2003 00:00 EST; left DIPCOT (nGy), right RIMPUFF (Gy)



Comparison of measured and calculated gamma dose rates for the case of 25/7/2003 (up) 22/6/2003 (down) for DIPCOT (left) and RIMPUFF (right)

Case	DIPCOT				RIMPUFF			
	NMSE	CORR	FA2	FB	NMSE	CORR	FA2	FB
250703	0.46	0.81	0.93	0.28	0.78	0.61	0.73	-0.15
220603	0.46	0.48	0.73	0.07	5.61	0.34	0.64	-0.75
081103	0.69	0.88	0.82	0.37	0.86	0.09	0.82	-0.11
251102	1.52	0.63	0.42	0.71	0.44	0.78	0.75	-0.24
151202	2.10	0.90	0.57	0.81	0.50	0.71	0.86	0.26
060603	1.20	0.45	0.56	0.32	6.29	-0.21	0.44	1.27
140603	0.68	0.51	0.27	-0.46	6.52	-0.13	0.46	0.06
130603	1.34	0.23	0.33	-0.23	9.26	0.03	0.40	-0.39
260603	0.83	0.46	0.50	-0.12	3.61	-0.21	0.13	0.90
170603	4.62	0.13	0.00	1.36	1.42	0.18	0.40	0.84
090703	5.73	0.31	0.00	1.43	4.98	0.05	0.10	1.35
291102	2.16	0.79	0.80	0.30	1.07	0.81	0.80	-0.08
131202	13.11	1.00	0.80	1.26	13.11	1.00	0.80	1.26
171202	1.55	0.89	0.50	0.68	2.30	0.73	0.60	0.83
070603	0.58	0.42	0.51	0.22	0.38	0.60	0.64	0.10
100603	1.06	0.06	0.50	-0.25	3.92	0.01	0.29	-0.48
All	**1.48**	**0.45**	**0.50**	**0.17**	**4.39**	**0.22**	**0.53**	**0.02**

*Statistical indices for model performance obtained by BOOT software **(gamma dose rate values paired in space and time).** Red identifies cases satisfying the model acceptance criteria*

CONCLUSIONS

Contour plots of calculated gamma radiation dose rates and accumulated doses, reveal similar behaviors between the two models in the majority of cases. They also show the effects of the changing wind direction during the simulated periods.

Based on the statistical indices, the models performance varies between cases. Overall, the median values of the indices are within the suggested ranges according to the BOOT documentation, with the exception of one index. This is a satisfactory result considering the rather strict requirement of pairing both in space and time that has been imposed for this evaluation exercise.