MODEL COMPARISON AT THE PARAMETER LEVEL WITHIN THE DUTCH-GERMAN COMMISSION FOR NUCLEAR FACILITIES IN THE BORDER REGION

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INTRODUCTION

In the framework of the emergency management program of the Dutch-German commission for nuclear facilities in the border region (NDKK), an ad-hoc workgroup investigates counteractions for nuclear emergencies in the neighbouring countries. The countermeasures are partly based on predictions using deterministic dispersion models. Therefore, it is important for cross-border nuclear emergency responses to assess the differences in both the atmospheric dispersion and radiation dose models. Since this comparison is on cross-border level, we focus on short-range models used in the two countries. Whereas the contemporary methods of the Harmonisation Community are based on the use of validation tools, this study consists of a comparison at the parameter level. A first round of comparisons was carried out with default parameters. After a harmonisation of some of the parameters, a second round of comparisons was performed.

INSTITUTES AND MODELS

Four groups, three German and one Dutch, participated in this model comparison. Their duties and models are described below. Table 1 gives an overview of some of the modelling characteristics.

The centre for nuclear-emergency management at RIVM acts as a technical back-office during nuclear emergencies advising the Dutch government. The model for short-distance prognosis of dispersion is TADMOD, a Lagrangian puff model in which a unit emission with constant emission rate results in a number of discrete Gaussian puffs, based on RASCAL 1.3. In addition to atmospheric dispersion, WinREM incorporates dose models (*Poley*, 1999).

BfS carries out orders regarding the German Nuclear Energy Act. The real-time online decision support system RODOS is employed. It uses for short-range atmospheric dispersion the module ATSTEP. This is a Gaussian puff model for distances up to 50 km with dispersion parameters according to the French-German model (*Isnard et al*., 2001).

TÜV Rheinland/Berlin-Brandenburg is a service company in the field of engineering safety. It acts as a consultant to the German Federal Ministry of Environment, resulting in an SSK-publication (1995) and the corresponding computer code PLUTO. The code uses a Gaussian plume model with the Karlsruhe-Jülich parameters (SSK, 1992). In a revision of the 1995- guide (draft SSK, 2002), the dispersion parameters according to the French-German model are used. The revised model will be abbreviated to LF02 and is used in the second round.

NLÖ carries out measures of the independent monitoring network of nuclear facilities in its federal state. It models dispersion and radiological effects with Lagrange simulation for aerosol transport (LASAT) developed by Janicke Consulting and dose modelling according to BMU (1989).

Table 1. Standard parameters of the models

Institute	RIVM	BfS	TÜV	TÜV	NLÖ
Model	WinREM	RODOS (ATSTEP)	PLUTO	LF02	LASAT
Inhalation					
Breathe rate (m^3/s)	3.25 E-4	2.58 E-4	3.9 E-4	3.9 E-4	3.5 E-4
Dose coefficients	NRPB [a]	ICRP [d]	BGA [g]	ICRP [d]	BGA [g]
Groundshine					
v_{dry} iodine (m/s)	1.0 E-2	5.0 E-3	1.0 E-2	1.0 E-2	1.0 E-2
v_{dry} aerosol (m/s)	1.0 E-2	5.0 E-4	1.5 E-3	1.5 E-3	1.5 E-3
Washout □ (s^{-1})					
I = 1 mm/h	2.2 E-4	8 E-5	7 E-5	7 E-5	7 E-5
1 < I < 10 mm/h	6.1 E-4	8 E-5 × $I^{0.8}$	7 E-5 × $I^{0.8}$	7 E-5 × $I^{0.8}$	7 E-5 × $I^{0.8}$
Correction factor	0.25	1	1	1	0.5
Dose coefficients	Kocher [b]	GSF [e]	BGA [g]	BfS [i]	BGA [g]
γ-submersion					
Correction factor	0.5	-	-	-	-
Dose coefficients	Kocher [b]	GSF [e]	BGA [g]	FG12 [j]	BGA [g]
Physical parameters					
Dispersion Parameters	National Model [c]	DFK [f]	Karlsruhe-Jülich [h]	DFK [f]	Karlsruhe-Jülich [h]

[a] *Bircha and Hutton* (1991); [b] *Kocher* (1983); [c] *Small Commission for Models* (1976); [d] ICRP Publication 72 (1995); [e] *Jacobs et al.* (1990); [f] *Isnard et al.* (2001); [g] BMU (1989); [h] SSK (1992); [i] BMU (2001); [j] *Eckerman et al.* (1993)

THE FIRST ROUND OF COMPARISONS: 2001

The first comparison consisted of 54 separate cases: six types of weather (see Table 2), three emission heights, 10, 70, and 100 m above ground level, and three emission terms (^{133}Xe: 10^{15} Bq, ^{131}I: 10^{14} Bq, and ^{137}Cs: 10^{13} Bq) during 8 hours. For each case the institutes were asked to calculate in their standard manner time-integrated concentration, deposition, as well as effective dose per path γ-submersion, groundshine, and inhalation (ingestion is not considered in this study) and thyroid dose, all as function of distance from the source, viz. 1, 2, 5, 10, 15, and 20 km at the plume axis, and at three off-axis locations. The evaluation of the radiological data was to occur after 12 hours.

Table 2. Meteo characteristics for the first round of comparisons

Meteo type	Stratification	Class	Wind speed at h = 10 m (m/s)	Rain intensity (mm/h)
1	Stable	F	3	0
2	Neutral	D	3	0
3	Neutral	D	3	0.5
4	Neutral	D	3	5.0
5	Unstable	A	2	0
6	Unstable	A	2	0.5

Results and discussion

Because not all programs were able to directly output the requested data, we could only use three models in the first round. The overlapping data of PLUTO, RODOS and WinREM consisted of the effective dose per pathway, the ground contamination and the thyroid dose, merely at the plume axis, and emission heights 10 and 70 m. In general it can be mentioned that the effects for different radiological values are similar. However, some data differ by more than a factor of 10. Furthermore, stability class A and F (meteo types 5, 6, and 1) bring about the most deviating prognoses.

Meteo types 2, 3, and 4 have, apart from rain intensity, similar dispersion characteristics. This allows one to focus on the effects of rain. The deposition of ^{137}Cs is largely dependent on the rain; moderate rain (meteo 4) compared to no precipitation (meteo 2) causes on a distance of 15-20 km an increase of the ground concentration by a factor of 170 for the results with PLUTO, around 25 for those of RODOS, but the results with WinREM show values only slightly increased. This can be explained by switching off the depletion of the cloud for the calculations with PLUTO, and strong discharges closer to the source for WinREM. Also the inhalation component of the effective dose shows that PLUTO data do not change on increasing rain intensity. The effects on the (total) effective dose *E* are shown in Figure 1 (for 10-m emission and ensemble of all nuclides). Most striking is the strong decrease of *E* in WinREM. This is an effect of washout and depletion of the cloud. In addition, for meteo type 2 RODOS shows lower values at 5 than at 10 km from the source.

Inhalation forms the bulk of *E* for the relatively short evaluation period of 12 hours. For meteo 1, 2, and 3 the models are in reasonable agreement. WinREM predicts relatively lower doses with respect to the other models for meteo 4, 5, and 6. The inhalation contribution to the effective dose is proportional with factor α to the thyroid dose. However, it is remarkable, that where α_{iodine} is constant for WinREM (17.9) and slightly different for RODOS and PLUTO (varying between 19-21), $\alpha_{caesium}$ varies largely from PLUTO (0.11) and WinREM (0.16) to RODOS (0.95).

Keeping in mind the discrepancies of the dry-deposition velocities v_{dry} for aerosols used in the three models (Table 1), the groundshine component of the effective dose varies as expected. WinREM's parameter is 20 times higher than the one used in RODOS, but a reduction of the groundshine to 25% mitigates the differences. The weight of groundshine to *E* is mostly not more than a few percent except for meteo 4 (moderate rain) on distant points, where it increases up to almost half. Finally, the γ-submersion component of *E* mostly contributes for only about 1%.

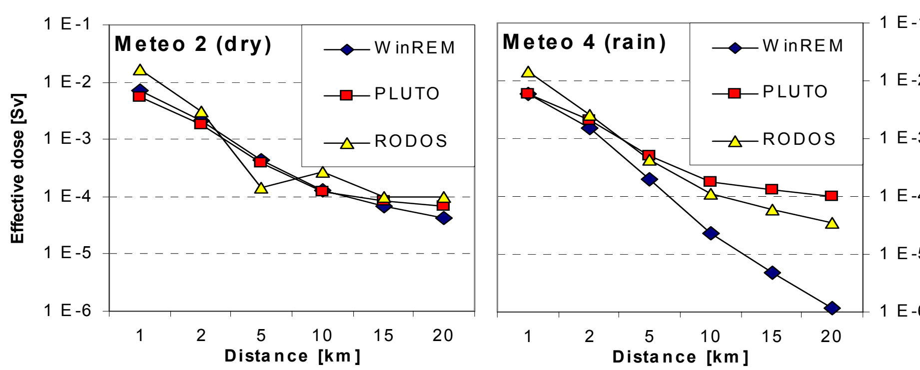

Figure 1. Effects of precipitation on the effective dose as function of distance (first round).

HARMONISATION

The German models already utilised comparable parameters, so the ones used by WinREM were harmonised. Its reduction factors for groundshine and cloudshine are set to unity to comply with the German models. Furthermore in WinREM, we adapted v_{dry} originally 1 cm/s for aerosols to 1.5 mm/s. The washout parameters for WinREM were discontinuous and 2.4~3.1 times higher. These were adjusted to the German values that are described by function of rain intensity.

THE SECOND ROUND OF COMPARISONS: 2002

The second comparison was a smaller exercise, with different scenarios. For this round only two meteo types (see Table 3), one emission height of 160 m, and two different source terms (^{131}I: 10^{14} Bq, and ^{137}Cs: 10^{13} Bq) for an emission of 8 hours were evaluated. For the four cases we calculated the effective dose per path and the thyroid dose. This was to be evaluated at six distances from the source: 0.9, 1.1, 1.9, 5.2, 9, and 22 km, after a considerably longer period of time 7 days, to comply to the German intervention levels.

Table 3. Meteo characteristics for the second round of comparisons

Meteo type	Stratification	Class	Wind speed at h = 10 m (m/s)	Rain intensity (mm/h)
1	Neutral	D	3	1
2	Stable	F	1	0

Results and discussion

The resulting effective doses for the models for meteo type 1 (neutral) agree within a factor 10 for most distances (Figure 2, left panel). Notable differences are the following:

- The RODOS results for the groundshine are a factor 10 lower than those of WinREM, LF02 and LASAT.
- The calculated γ-submersion of LF02 is a factor 40-100 lower than predicted by the other models for ^{131}I, and with respect to WinREM also for ^{137}Cs. However, it contributes for less than 1% to E in this case.

The results of the models using meteo 2 (stable) show more differences (Figure 2, right panel), which can be explained by pronounced differences in modelling of the stable stratification class F. On the whole the following points can be made:

- At distances larger than 5 km, the calculated effective dose using WinREM is relatively high. The first round indicated that “stable” conditions already gave high doses for inhalation and groundshine. In the second round, after switching off the reduction of groundshine to 25%, E becomes more extreme. Groundshine contributes in WinREM for almost 50% to E, which is high.
- Compared to the other models, LF02 predicts a relatively small contribution of groundshine to the effective dose.
- LASAT predicts a strong gamma-submersion nearby the source, but calculates relatively low values for inhalation and groundshine on all points.
- For the RODOS results the increase of E versus distance is less pronounced than those of the other models. Possibly, this could be ascribed to a relatively high roughness length, resulting in more dispersion in lateral direction close to the source.

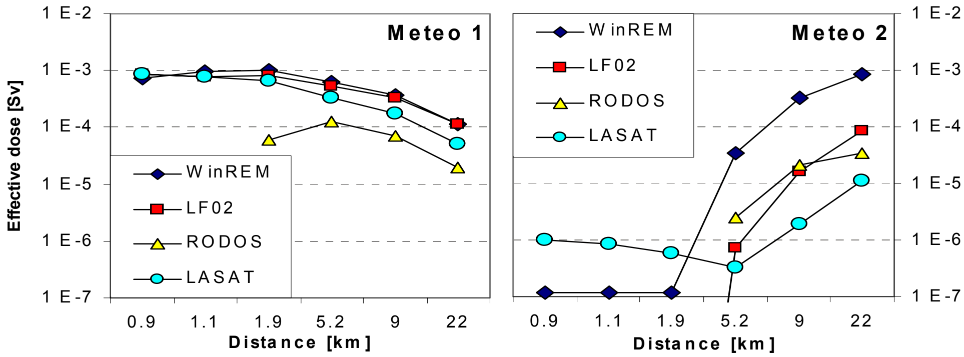

Figure 2. Effective dose as function of distance (second round).

CONCLUDING REMARKS

The agreement of the models to be used at cross-border nuclear emergencies is for the cases investigated here in general within a factor 10. Especially stability class D (neutral) turns out to be uniformly modelled. After harmonising some of the parameters, also the stability class D including precipitation is consistently prognosticated. However, difficulties are encountered for stable and unstable stratifications, even after harmonisation of parameters. This requires further investigation of the atmospheric dispersion parameterisation and dose modelling.

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