ASSESSMENT OF GAUSSIAN AND LAGRANGIAN DISPERSION MODELS IN JRODOS FOR DIFFERENT TERRAINS AND SOURCE TERMS

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Introduction and description of the research problem

Atmospheric dispersion modelling plays a crucial role in emergency preparedness, response planning, and dose estimation during nuclear accidents.

Different dispersion models have been developed to simulate the movement of pollutants in the atmosphere. The choice of model is critical in a real accident situation, while some models offer a more detailed look at the spread of radionuclides from the accident site, others offer faster results and thus faster decision support advice.

The aim of this study was to apply two different dispersion models to SMR and conventional NPP source terms in different terrains to monitor the differences in calculated acute effective doses over 24 hours to the public without applying any countermeasures.

Based on the resulting observations, the study presents the importance and guidelines on the selection of dispersion models in different use cases.

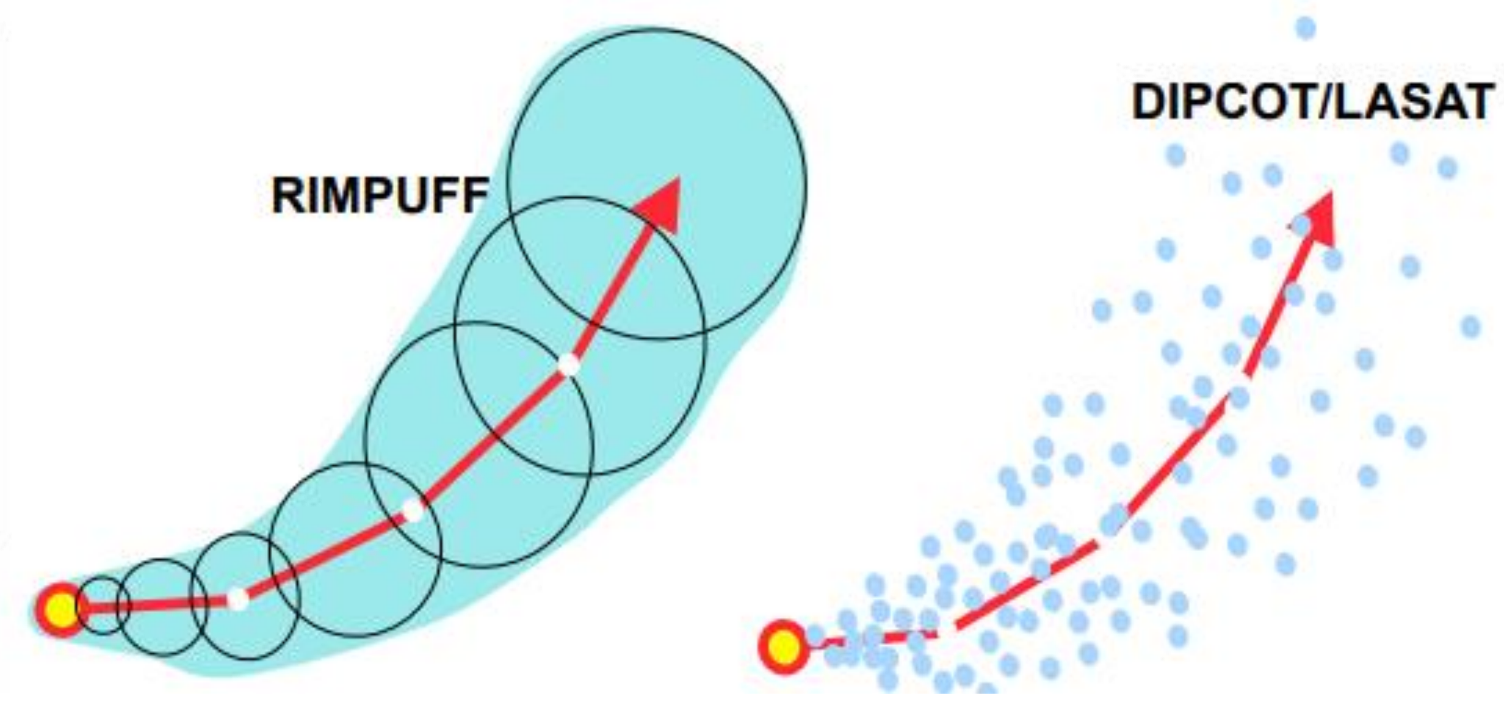

Figure 1. Trajectory estimation methods in the Gaussian puff model (left) and Lagrangian particle model (right).

Table 1. Isotopes used in the simulations.

Isotope	Olkiluoto (Bq)	TVA (Bq)	Isotope	Olkiluoto (Bq)	TVA (Bq)
Cs-137	$2.4 \cdot 10^{15}$	$8.23 \cdot 10^{11}$	Te-127m	$1.3 \cdot 10^{14}$	$2.65 \cdot 10^{10}$
Cs-134	$2.6 \cdot 10^{15}$	$1.17 \cdot 10^{12}$	Kr-87	$6 \cdot 10^{15}$	$1.02 \cdot 10^{13}$
I-131	$2.5 \cdot 10^{16}$	$6.28 \cdot 10^{12}$	Kr-88	$7 \cdot 10^{16}$	$2.80 \cdot 10^{13}$
Sr-89	$1.1 \cdot 10^{14}$	$2.04 \cdot 10^{11}$	Xe-133	$1 \cdot 10^{18}$	$1.61 \cdot 10^{15}$
Sr-90	$7.2 \cdot 10^{12}$	$6.90 \cdot 10^{10}$	Xe-135	$4.5 \cdot 10^{17}$	$1.38 \cdot 10^{14}$

Methodology

Two different dispersion models were used in the JRodos software- The Gaussian puff model called RIMPUFF and the Lagrangian particle model called DIPCOT.

The main difference between the models comes from their method of estimating the plumes trajectory (Figure 1).

The accident was simulated to take place in the Muehlberg NPP site in Switzerland. The Tennessee Valley Authorities small modular reactor source term was used to simulate an accident with a SMR. And Olkiluoto 1&2 reactors large accident source term was used to simulate an accident with a conventional NPP. The isotopes and their corresponding activities are presented in Table 1. The weather data was inserted manually to manipulate the directional movement of the plume over flat terrain and over difficult terrain (Alpine mountain range).

The simulations were done in a 100 km calculation grid for close range results and in a 200 km calculation grid for longer distances results.

Results

The SMR accidents don't meet the dose criteria of 10 mSv acute effective dose in any of the simulations. With the conventional NPP source term the 10 mSv effective dose area is smaller in difficult terrain simulations (Table 2 and 3)

Both dispersion models produced similar results in the 100 km range simulations (Figure 3).

Differences become apparent in the 200 km range simulations and especially over the difficult terrain, where the changes in doses correspond to changes in terrain (Figure 2 and 4).

Lagrangian particle model produces more fluctuating look at the doses, while the Gaussian puff model tends to retain its dose values regardless of changes in terrain.

Table 2. Distances at which the dose criterion are exceeded in flat terrain simulations.

	TVA	Olkiluoto
RIMPUFF	-	16 km
DIPCOT	-	25 km

Table 3. Distance at which the dose criterion are exceeded in difficult terrain simulations.

	TVA	Olkiluoto
RIMPUFF	-	9.9 km
DIPCOT	-	21.3 km

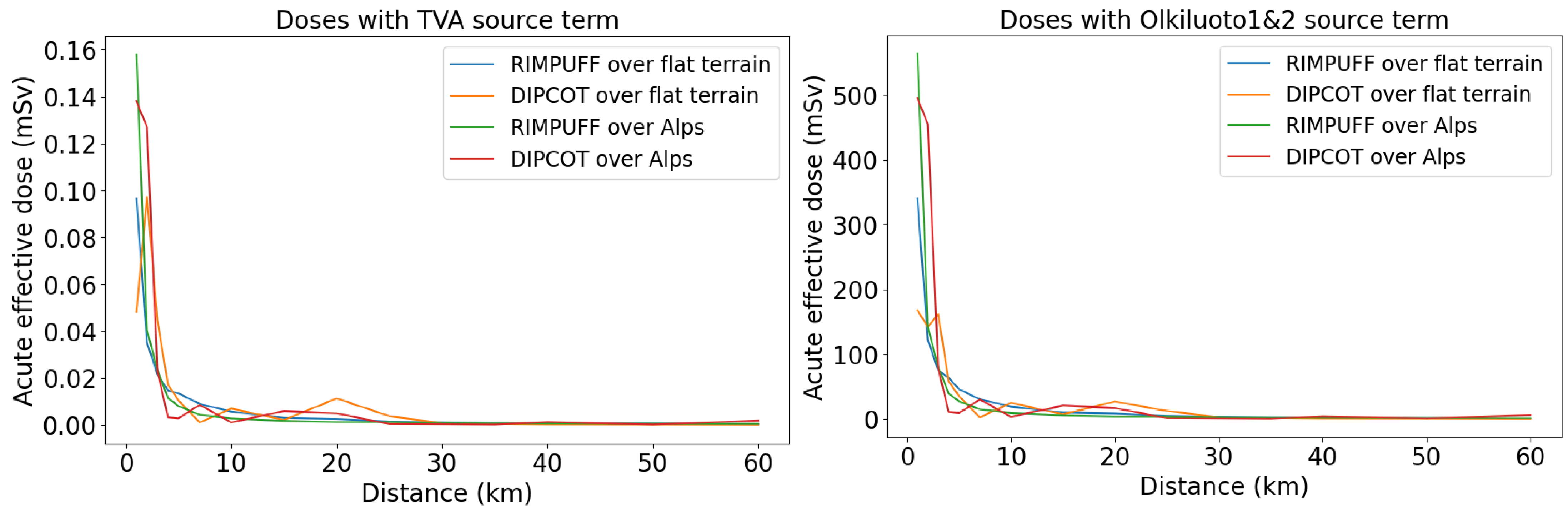

Figure 3. Acute effective doses in closer range simulations. SMR based accident results (left) and conventional NPP based accident results (right).

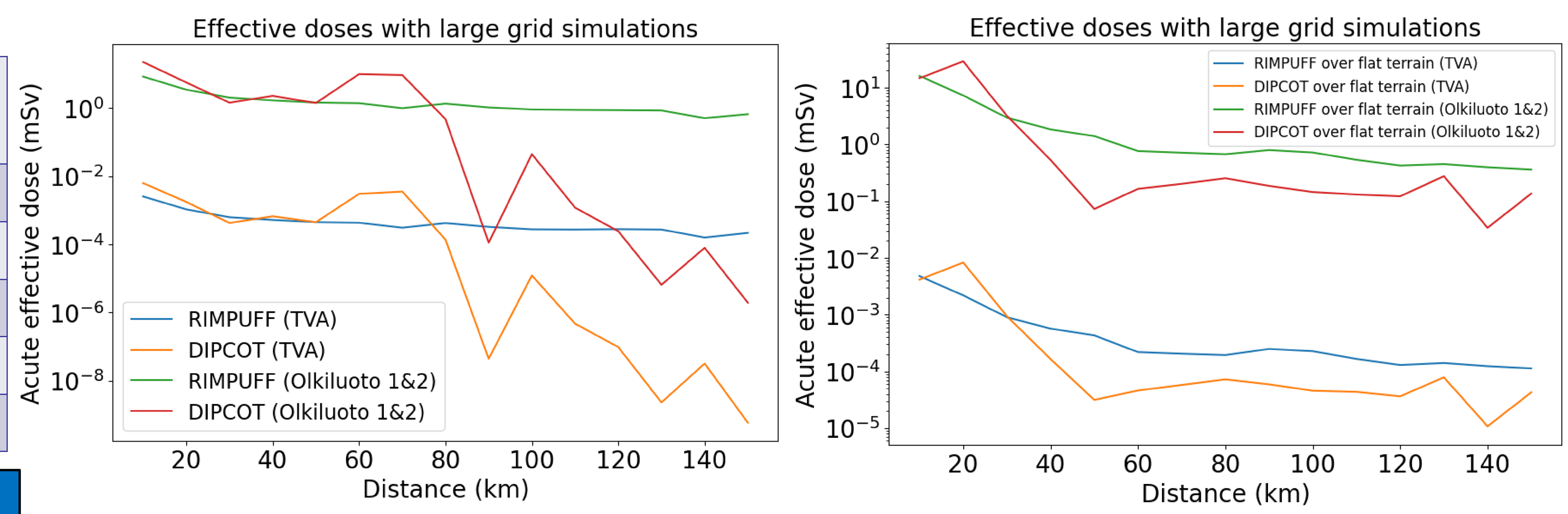

Figure 4. Acute effective doses in longer range simulations. Difficult terrain results (left) and flat terrain results (right).

Conclusions

- The dose values of the simulations showed comparable results with both dispersion models in shorter range simulations.
- The longer range and difficult terrain simulations show the advantage of the Lagrangian particle model over the Gaussian puff model. While the Gaussian model retains the doses regardless of terrain, the Lagrangian models dose values correspond to changes in the landscape.
- In detailed safety evaluation the Lagrangian particle model would be more suitable for simulations, offering a more detailed overview of doses in the plumes path. But the Lagrangian particle model is computationally heavier (7 times longer in this case) and thus in real accident situations where the dose must be evaluated for emergency actions, the Gaussian puff model would be more advantageous, giving an estimate of the acute effective dose in closer range with shorter computational time.

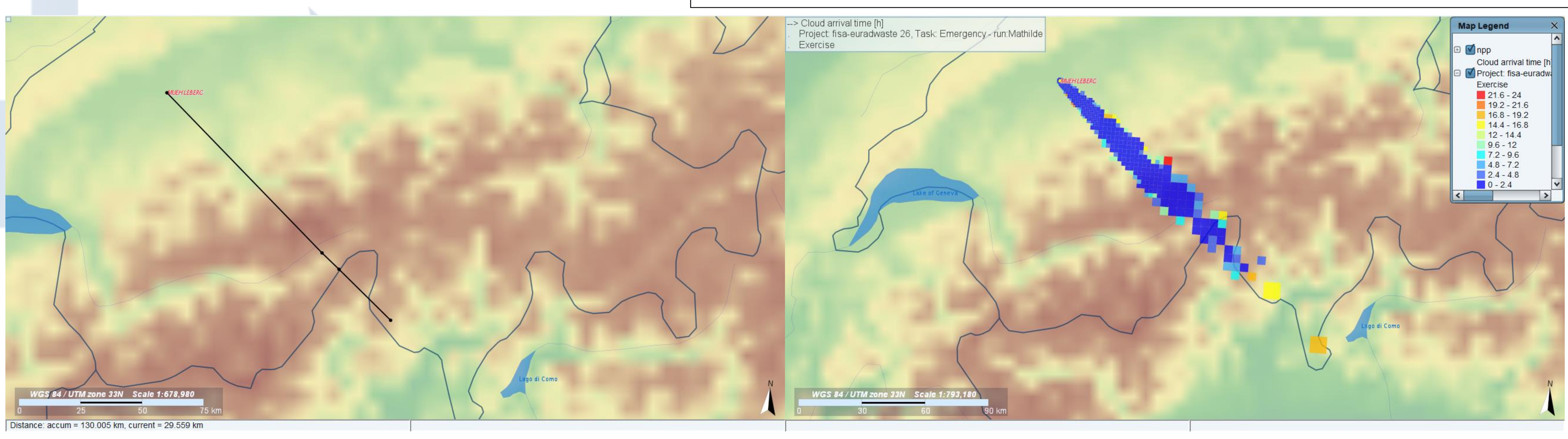

Figure 2. Movement of the plume over difficult terrain (Lagrangian particle model simulation). The markings on the left figure show the dose peak and decrease areas.

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