SnT 2019
CTBT: SCIENCE AND TECHNOLOGY CONFERENCE

Atmospheric Dispersion and Ground Level Deposition of Cs-137 Released From Chernobyl Nuclear Power Plant Accident

T2.4-P5

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ABSTRACT

Even though many studies have been carried out to calculate the effects of the Chernobyl Nuclear Power Plant accident of 26 April 1986, even today, major uncertainties about impact of the accident exist. None of the available source term, used in atmospheric transport models, produces a good representation of the atmospheric dispersion and ground level deposition of radionuclides. In this study, atmospheric dispersion and ground level deposition of Cs-137 released from Chernobyl nuclear power plant was simulated with the Lagrangian particle dispersion model FLEXPART . The source term estimated by Evangeliou et al. (2017) was used with ECMWF and NCEP reanalysis datasets as meteorological input data. The results were visualized with the Quicklook plotting tool and then compared with each other and with the Cs-137 contamination map of Europe after the Chernobyl accident (Cs-Atlas, EC / IGCE / Roshydromet/ Minchernobyl / Belhydromet, 1998). Some differences were observed between meteorological datasets. Moreover, the comparison with Atlas demonstrated that while in some regions the Cs-137 depositions are reproduced well, while in other regions significant deviations are found.

INTRODUCTION

After the most catastrophic nuclear accident was happened in 26 April 1986, CHERNOBYL:

- Aproximately 14 x 10^{18} Bq of radioactivity was released into the environment,
- 30 workers and firemen died within 3 months and several further deaths later,
- About 350,000 people were resettled into less contaminated areas (World-Nuclear, 2019).

After the accident various studies were conducted to demonstrate the effects of the accident. First studies published after the accident were focused total amount of the emitted radionuclides (UNSCEAR, 2000).

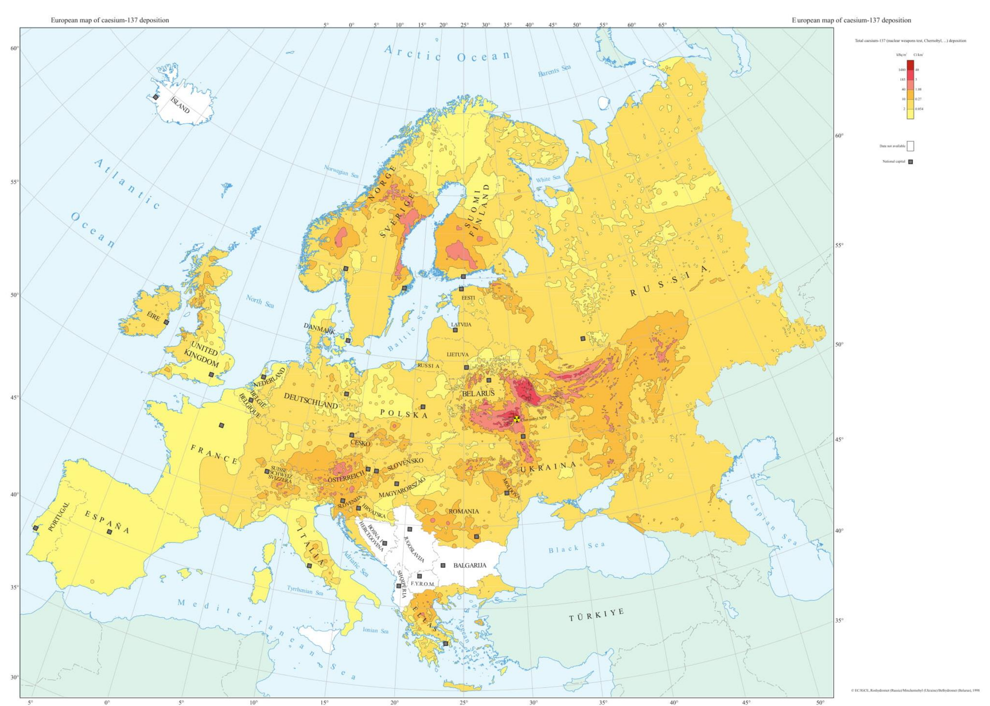


Figure 1. Surface ground deposition of caesium-137 released in Europe after the Chernobyl accident (De Cort et al., 1998). Copyright: EC / IGCE / Roshydromet/ Minchernobyl / Belhydromet, 1998

- **Brandt et al. (2002)** developed a source term quite compatible with the observations for Cs-137, Cs-134 and I-131 using a mathematical model.
- **Talerko (2005)** also conducted a simulation with an atmospheric dispersion model for Cs-137 released from Chernobyl accident.
- **Evangeliou et al. (2017)** presented a comprehensive source term for Cs-137, Cs-134 and I-131 released from Chernobyl using FLEXPART.

METHOLOGY

- **FLEXPARTv9.0.3** (Stohl et al., 1998, 2005) was used to estimate atmospheric dispersion and ground level deposition of **Cs-137** released from **Chernobyl Accident**.
- FLEXPART needs 3D meteorological fields and three different reanalysis data were used; NCEP/NCAR, ERA-40 (ECMWF), ERA-INTERIM (ECMWF).

Table 1. Some configurations of simulations.

	Case - 1	Case - 2	Case - 3
Met. Input Data	NCEP/NCAR	ERA-40	ERA-INTERIM
Input Resolution	0.5 x 0.5 Degree	0.5 x 0.5 Degree	0.75 x 0.75 Degree
Source Term	Evangeliou et al. (2017)	Evangeliou et al. (2017)	Evangeliou et al. (2017)
Simulation start	25/04/1986 - 22.00 (UTC)	25/04/1986 - 22.00 (UTC)	25/04/1986 - 21.00 (UTC)
Simulation end	09/05/1986 - 22.00 (UTC)	09/05/1986 - 22.00 (UTC)	15/05/1986 - 00.00 (UTC)
Release start	26/04/1986 - 00.00 (UTC)	26/04/1986 - 00.00 (UTC)	25/04/1986 - 22.30 (UTC)
Release end	06/05/1986 - 00.00 (UTC)	06/05/1986 - 00.00 (UTC)	06/05/1986 - 00.00 (UTC)
Output resolution	0.5 x 0.5 Degree	0.5 x 0.5 Degree	1 x 1 Degree
Output frequency	1-hour	1-hour	3-hour

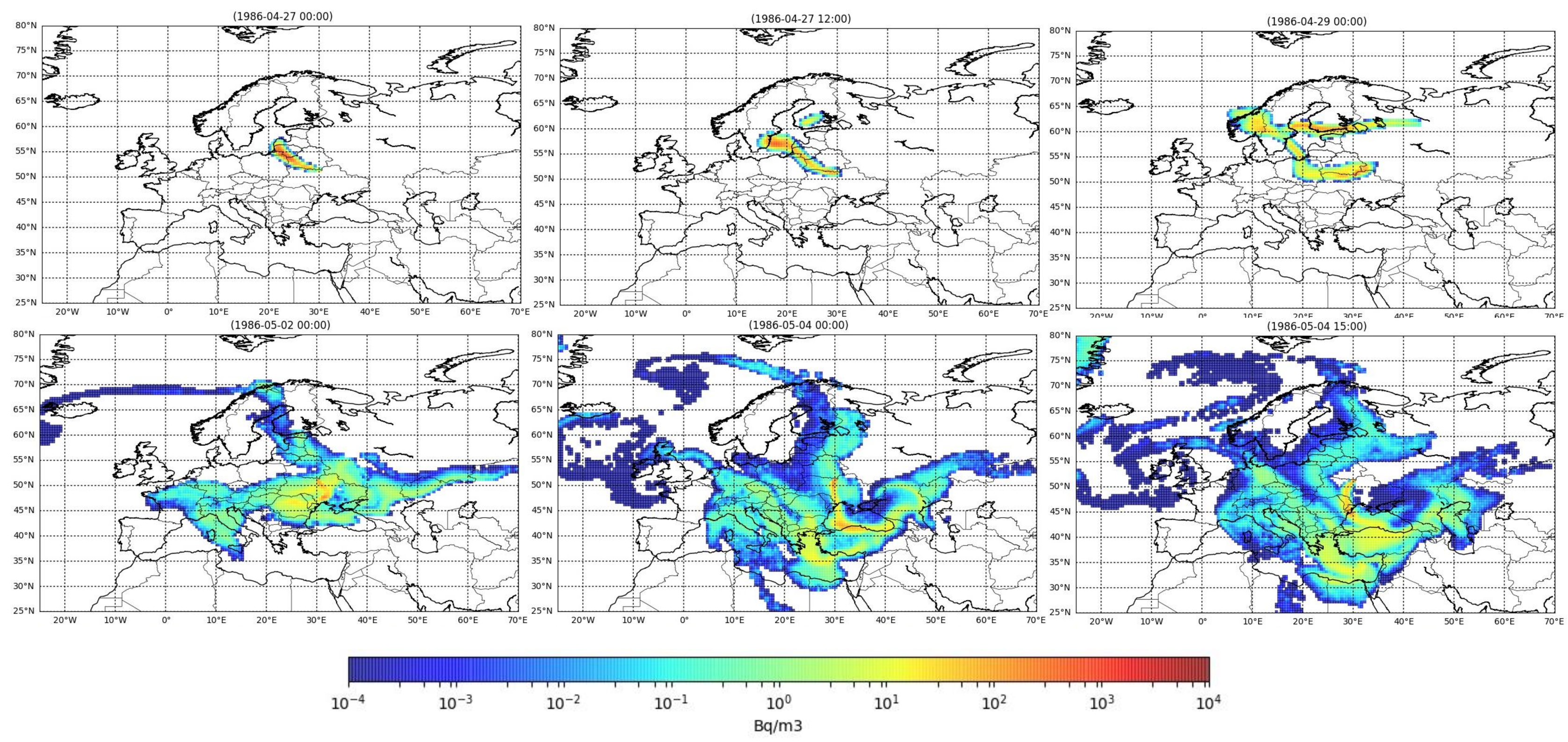
- Evangeliou et al. (2017)assumed four different particle size for each radionuclides. We assumed one particle it instead of this complex approach.

Table 2. Characteristics of the specie used in this study.

Specie	Diameter (m)	Std. Dev.	Density (kg/m3)
Cs-137	1.50E-06	2	2.50E+03

RESULTS

- Results were visualized with the **Quicklook** plotting tool.



- **ERA-40 and ERA-INERIM** gave better results than **NCAR/NCEP.**
- Around of the Chernobyl, Scandinavian countries, some places in Central Europe, Western Thrace, East of the Black Sea has relatively high deposition values.
- The spatial distribution of Cs-137 (especially in ERA-40) deposition has relatively consistency with Atlas.
- However, results doesn't represent the some of highly contaminated areas.
- Over-estimated values are available north of the Russia.
- ERA-INTERIM plot coarser than ERA-40 result due to the output resolution and frequency.

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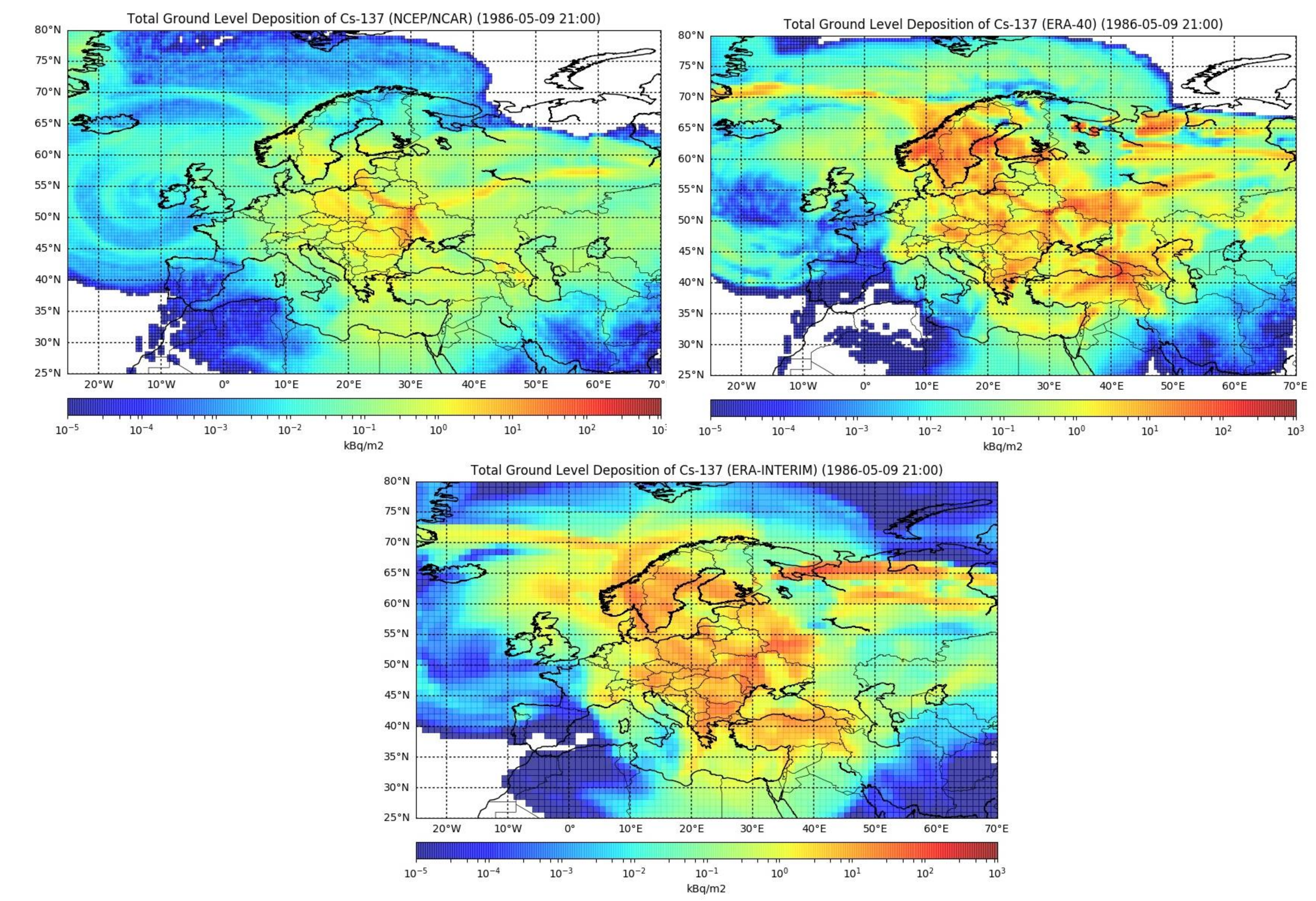
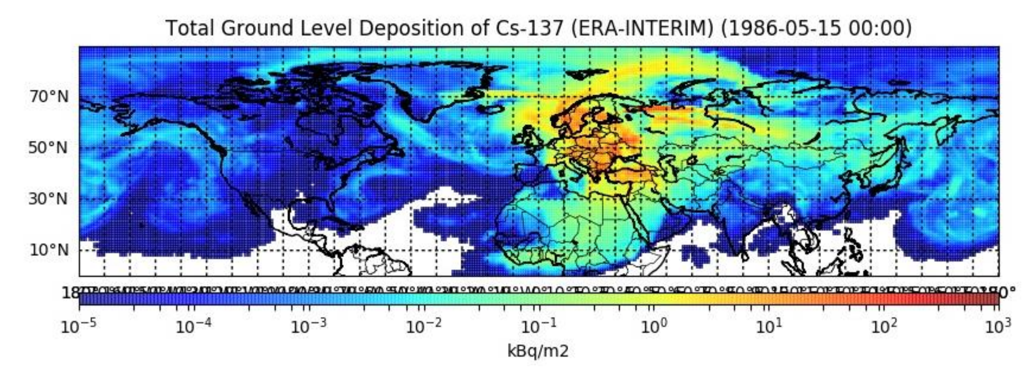


- FLEXPART also was runned for whole northern hemispher using ERA-INTERIM data.



CONCLUSIONS

- The last source term published in literature has still some deficiencies representing the distribution of the Chernobyl depositions in some region. That's why, source terms should be improved.
- It is clearly reveal that meteorological data is significant factor on estimation of the atmospheric dispersion and ground level depositions. ECMWF datasets (ERA-40 and ERA-INTERIM) gave better results, while NCAR/NCEP dataset is not sufficient to represent the depositions. Better results can be obtained using new datasets like ERA-5.
- Hemispheric study can be interesting for long range effect and should be improved.

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