An analysis of the evolution of radioactive contamination using the FLEXPART model

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Introduction

Radioactive material emitted into the atmosphere following a nuclear power plant accident may have crucial effect on human health and the biosphere in the affected area. Inhalation of radioactivity is related mainly to the cloud, however, deposited radioactive contaminants remain on the ground, therefore leading to a dose burden from external exposure and ingestion of contaminated food and water, as well as from inhalation of resuspended particulates.

Contributing significantly to dose consequences, iodine needs special care and attention. Among the many iodine isotopes evolving as fission products in nuclear reactors, ^{131}I, with it's half-life of 8 days, is considered to be the most relevant, therefore plays a major role in safety analyses. The physical forms of iodine isotopes emitted into the air in the course of an accident are dominantly either particulate or gaseous. However, the ratio of the two may vary significantly. Deposition depends on the forms of the nuclides and the actual meteorological conditions.

The biological role of iodine in the human body makes it even more important to evaluate. Iodine is necessary for the thyroid to function properly. Since stable and radioactive iodine isotopes are indifferent for the thyroid, in case of iodine deficiency radioactive iodine – incorporated through inhalation – may get into the thyroid and by decaying it causes a continuous inner radiation.

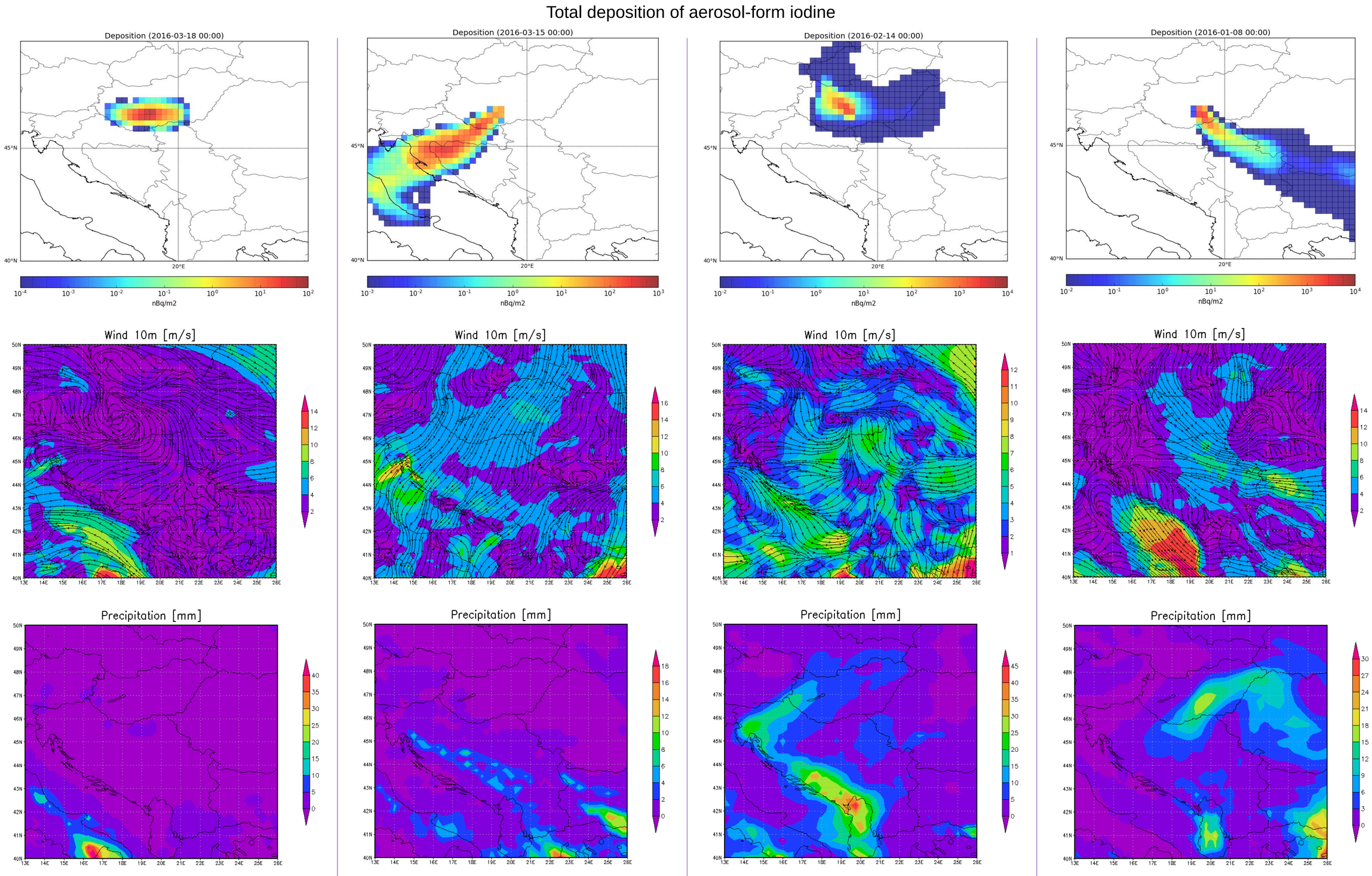
Methods

In this work we analyzed the environmental consequences of a hypothetical radioactive emission from Paks Nuclear Power Plant using the FLEXPART Lagrangian particle dispersion model, with special regard to iodine species. Dispersion and deposition of two forms of ^{131}I has been analyzed and compared.

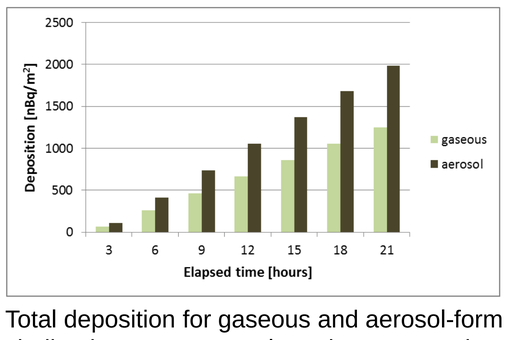
The source term was defined to be a unit of 1 Bq/hour with a duration of 6 hours.

In order to account for the differences in the distribution and deposition of pollutants under different weather conditions, we performed the same analysis using a variety of input meteorological datasets that have been selected to exemplify weather situations with strong and small winds without precipitation and those with rain and snow.

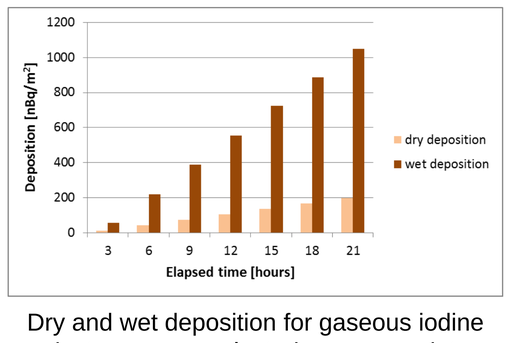
Meteorology and the affected areas



Temporal evolution of surface activity concentrations



Total deposition for gaseous and aerosol-form iodine isotopes on a selected receptor point



Dry and wet deposition for gaseous iodine isotopes on a selected receptor point

Conclusions

- In case of windless weather conditions the evolving cloud remains in the vicinity of the source, leading to higher activity concentrations in the surrounding area. Stronger winds, on the other hand, transfer the majority of pollutants further from the emission point, thereby leave smaller contamination around the source. However, they cause the plume to spread over a larger area.
- Wet deposition, in the presence of precipitation, is apparently dominant over dry deposition, adding up to at least 80% of the total deposition on the receptor points in examination.
- Deposition rate of iodine in aerosol form is in most cases considerably higher than that of gaseous iodine.
- Wet deposition of aerosol-form iodine generally exceeds that of gas-phase iodine, while surface concentrations from dry deposition are higher for gaseous iodine.