RADIOLOGICAL IMPACT OF REGULAR EMISSIONS FROM INDUSTRIAL SOURCES: OPS AND THE GAUSSIAN PUFF MODEL NPK-PUFF COMPARED

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INTRODUCTION

The industrial processing of ores can lead to the release of elevated concentrations of naturally occurring radionuclides in the environment. In the Netherlands, the industrial plant which accounts for the highest discharge to air of the radionuclide polonium (specifically the isotope with atomic mass 210, ^{210}Po, which is a product of the natural fission of the most abundant uranium isotope) has an operating permit from the Ministry of the Environment. A maximum level for the radiological impact caused by the industrial emissions to air is defined in the permit. The industry is accountable for compliance with the granted limit, and is required to report emissions to the Ministry. The radiological impact of the emissions can be assessed using atmospheric dispersion models.

ATMOSPHERIC DISPERSION MODELS FOR RADIOLOGICAL IMPACT

The Laboratory for Radiation Research of RIVM makes an assessment of the radiological impact of regular emission sources, and reports to the Ministry. The assessment is based on emission data reported each year by the industry. The atmospheric dispersion is modelled using version 4.1 of the Operational Priority Substance (OPS) model which is described below.

For emergency preparedness, such as a large-scale nuclear accident, the Laboratory for Radiation Research relies on NPK-PUFF, a real-time dispersion model, combined with meteorological predictions. Since the computational performance of this model has improved, it is now possible to envisage its application to the modelling of regular emissions. We present here the preliminary result of a comparison of dispersion calculations with NPK-PUFF and OPS for emission from the industrial plant mentioned above.

OPS

OPS (*van Jaarsveld, J.A.*, 2004) is a long-term Lagrangian transport and deposition model that describes relations between source and receptors. Concentration and deposition values are calculated for a number of typical situations: the long-term value is obtained by summation of these values, weighted with their relative frequencies. All relations governing the transport and deposition process have been solved analytically. The relative occurrence of specific meteorological situations is calculated within a pre-processor, with the annual average made available to users.

NPK-PUFF

NPK-PUFF is a Gaussian puff model (*Verver, G.H.L. and F.A.A.M. de Leeuw*, 1992) for calculating air and ground concentrations at receptor points. The meteorological information is provided by HIRLAM analysis fields on a 55 km x 55 km grid (interpolation between the available meteorological data takes place on the receptor grid). HIRLAM, the HIgh Resolution Limited Area Model (*Undén, P.*, 2002), is the operational numerical weather forecasting system for Europe at the Royal Dutch Meteorological Institute, KNMI. The HIRLAM fields are now available on a finer (11 km x 11 km) grid, although this is not yet implemented in NPK-PUFF. Outside the available HIRLAM area, NPK-PUFF uses ECMWF meteorological fields. For details, development and validation of the NPK-PUFF transport model, see *Eleveld, H.* (2002), *Bijwaard, H, and H. Eleveld* (2002), and *Kok, Y.S. et al.* (2004).

The NPK-PUFF model has been developed for rapidly simulating emissions which are a consequence of accidental releases, lasting a few hours at most. Recent numerical improvements have made it possible to apply the same model to regular emissions spanning over one month. This calculation takes approximately 10 minutes real time on a Linux workstation.

RATIONALE BEHIND THE COMPARISON

The meteorological statistics of OPS, which defines the period for which the calculations are representative, is pre-determined in the meteorological pre-processor of the model and it is based on data from the meteorological stations in the Netherlands. This notwithstanding, a first assessment of the radiological impact of this plant for Belgium has been made with the OPS model, relying on the extrapolation of the meteorological data beyond the Netherlands (*Tanzi, C.P.,* 2007).

The meteorological statistics of OPS is available for the individual years since 1981, in addition to the climatological data based on the 1990-99 decade. While in principle a specific data file with meteorological data can be provided, this possibility is currently not available to users, such as our Laboratory for Radiation Research: this precludes the possibility of studying the influence of specific weather conditions on the dispersion of the contaminants.

For our assessment purposes, a monthly-averaged meteorology is highly desirable, specifically in cases where measurements in the vicinity of the plant could be available. Monitoring on a time scale shorter than a year is advantageous also in cases where the actual releases would be close to the permitted level. As the plant is situated near the Dutch-Belgian border, information on the environmental impact beyond the Netherlands is also desirable (HIRLAM fields extend over Europe).

For these reasons we are exploring the possibility of extending the application of the NPK-PUFF model, developed for nuclear accidents, to the modelling of regular emissions. In case of a nuclear accident, the predictive part of the HIRLAM meteorology ensures a realistic modelling of the dispersion. For regular emissions, the meteorological fields are HIRLAM fields based on actual observations.

AIR CONCENTRATION

Emission to air from the plant is all-year round from a 55 m high stack with 1.5 MW heat content. The total yearly emission of the polonium isotope ^{210}Po to air is a few milligrams. For the present comparison, all particles have been chosen with size < 1 micron, which is close to known measurements (*Tanzi C.P. and H. Eleveld*, 2005). Fig. 1 shows the concentration in air calculated by the two models for the year 2005.

OPS

NPK-PUFF

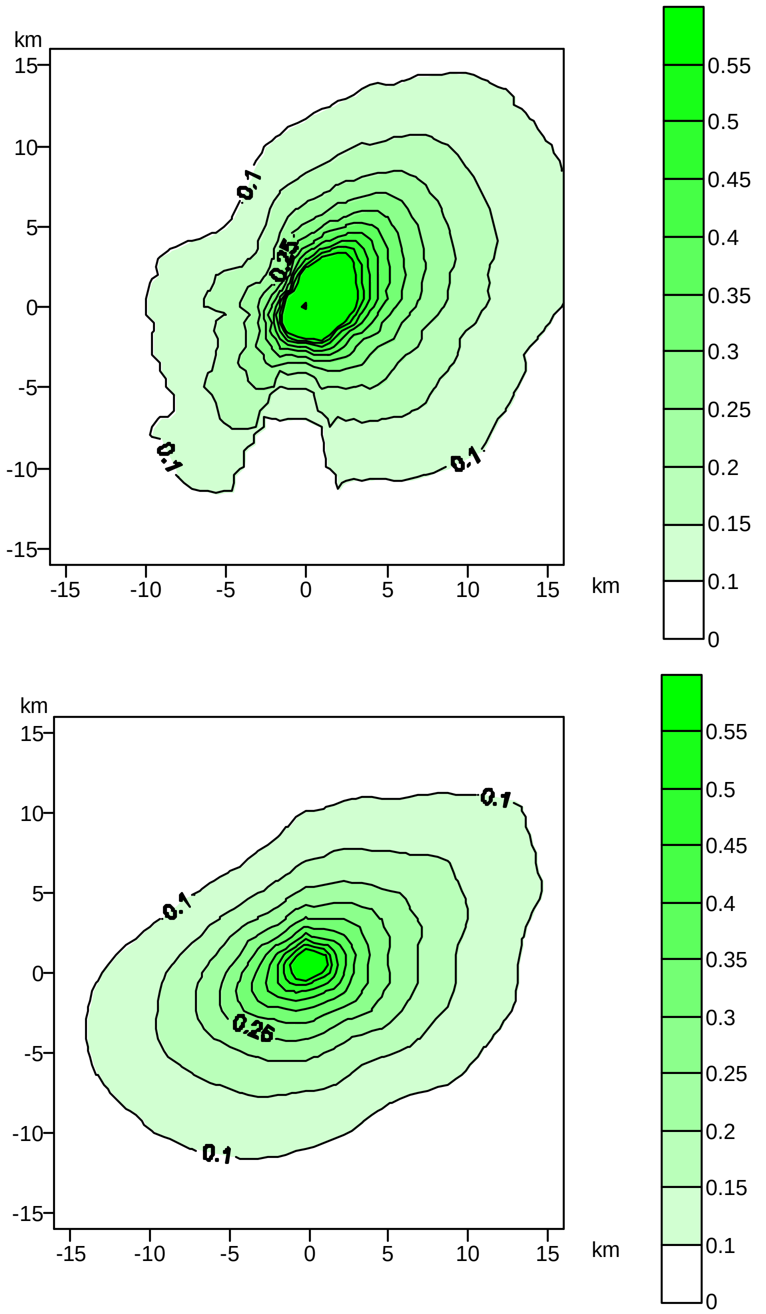

Fig. 1; Concentration in air (in mBq/m^3) from the continuous emission, over the year 2005, of 500 GBq of the polonium isotope ^{210}Po: OPS model (top) and NPK-PUFF model (bottom). The distance between receptors is 0.5 km. This comparison shows auspicious agreement.

Monthly analysis

In *Tanzi, C.P. and H. Eleveld* (2005) a good correlation over 17 years was shown between the modelled concentration in air at one OPS receptor at 3 km from the plant and the wind direction measured at a meteorological station (*KNMI*, 2007) situated in the vicinity of the plant. Similarly, with the NPK-PUFF model, we have examined in a 55 km x 55 km grid around the source the correlation between wind direction and the total concentration in air of the contaminant in the four quadrants. Results are shown in Fig. 2. The correlation coefficient varies between 0.56 and 0.85 for all quadrants.

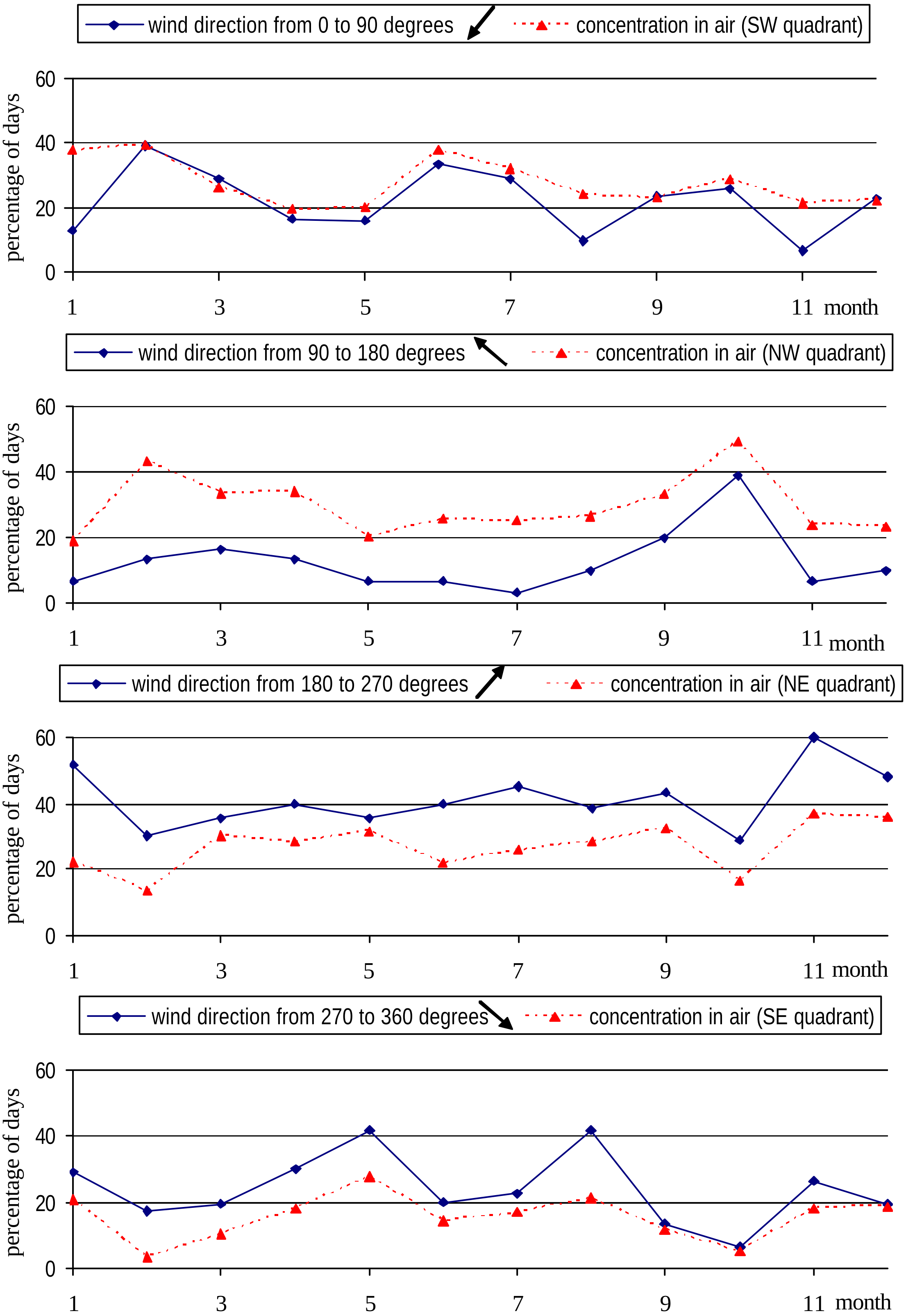

Fig. 2; Correlation between wind direction and modelled contaminant concentration in air. Within the grid calculation field of NPK-PUFF, the monthly sum of the contaminant concentration in air in the four quadrants is shown (normalized to the total in the calculation grid), together with the percentage of days for each month in 2005 when the wind blows in the direction of each quadrant. The correlation coefficient varies between 0.56 and 0.85.

CONCLUSIONS

The possibility of using the air dispersion model NPK-PUFF for regular industrial emissions is investigated. The preliminary results for aerosols show good agreement between the two models, and good correlation between calculated concentration in air and wind fields. Ongoing developments should resolve a number of outstanding issues before NPK-PUFF can actually be used for radiological assessment of regular emission. This includes the implementation of higher resolution meteorological fields, as the present 55 km x 55 km grid is too coarse for dose assessment, where dwellings are as close as 3 km from the industrial source. Stay tuned.

ACKNOWLEDGMENTS

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