Radiological and non-radiological environmental impact assessment of Estonian power plants

Wouter Slechten

Master of Nuclear Engineering Technology

1975

Modeling results for the year 1975 can be seen in figure 4. The same tendencies as in 1971 are observed. A mean value of 9,22 $mg/m^2.d$ which is significantly lower than the 1971 predictions. 75% of the results is predicted below 11,00 $mg/m^2.d$, the predicted maximum is 614,45 $mg/m^2.d$. The estimated average dose rates are 1,88 $mBq/m^2.d$ and a maximum dose rate of 125,35 $mBq/m^2.d$. This still constitutes a significant portion to the natural background activity,

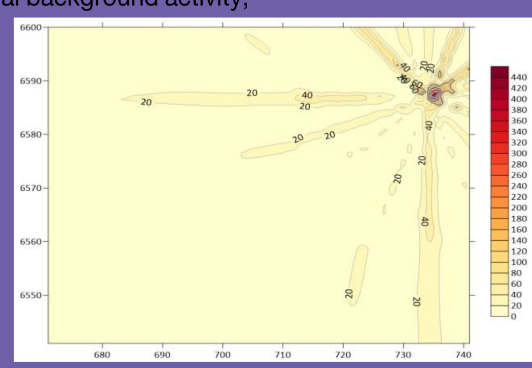

Figure 4: WGBM contour plot ('Heatmap') for the year 1975 modeling results in $mg/m^2.d$

1971

Modeling results for the year 1971 can be seen in figure 3. Maximum concentrations occur in the vicinity of the source points. One of these source points is more profoundly outspoken due to higher fly ash emission rates. The mean deposition value was 46,06 $mg/m^2.d$. The maximum predicted value was 1421,73 $mg/m^2.d$. 50% of the results were situated below 18,42 $mg/m^2.d$. Dose rates were found to be on average 9,40 $mBq/m^2.d$ while maximum dose rates were found to be 290,03 $mBq/m^2.d$. This constitutes 20-28% of the natural background activity (92-133 $Bq/m^2.y$)

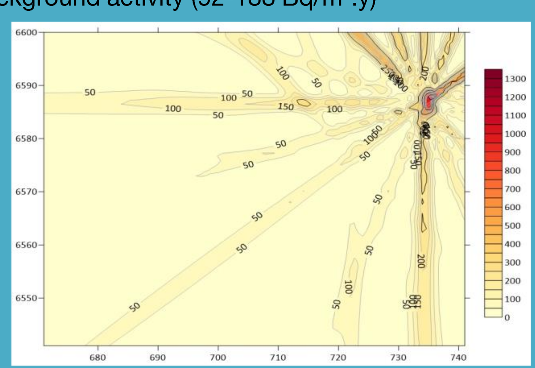

Figure 3: : WGBM contour plot ('Heatmap') for the year 1971 modeling results in $mg/m^2.d$

Comparison to the AEROPOL model

11-12 million tons of oil shale, containing various amounts of natural radionuclides, is burned annualy in the Narva oil shale-fired power plants. This combustion process accounts for 90% of the Estonian electricity production and makes the oil shale industry the largest producer of NORM (Naturally Occurring Radioactive Materials).[1] 2 atmospheric dispersion models namely WESTIGAUSS, a model used & developed by the SCK-CEN, and IFDM were compared to the AEROPOL model. WESTIGAUSS and IFDM were first compared to snow measurement to determine their accuracy. The IFDM model predicted an average snow deposition of 11,63 $mg/m^2.d$ while the average snow deposition is 31,83 $mg/m^2.d$. However, no correlation to the snow measurements was found. The WESTIGAUSS code was successfully extended to include three new features: treatment of multiple sources (and therefore sources that are not centrally located), a rectangular grid (as well as the original polar one) and a time dependence of the source. Three iterations were of the WESTIGAUSS code were developed. The first 2 use Pasquill-Gifford parametrization, the third uses the Bultynck-Malet parametrization. The first WESTIGAUSS iteration showed a mean snow deposition of 189,07 $mg/m^2.d$, but both models showed bad correlation to both the snow measurements as well as the AEROPOL results. The third model showed a better correlation, as shown in figure 1. Therefore this model was used in modeling reference years 1971, 1975, 1985, 1995 and 1999. Figure 2 shows the AEROPOL results compared to the taken snow measurements. Deposition is hypothesized to be proportional to the emitted fly ash. ^{210}Pb was used as a reference radionuclide in estimating radiological impact in accordance with the AEROPOL research.

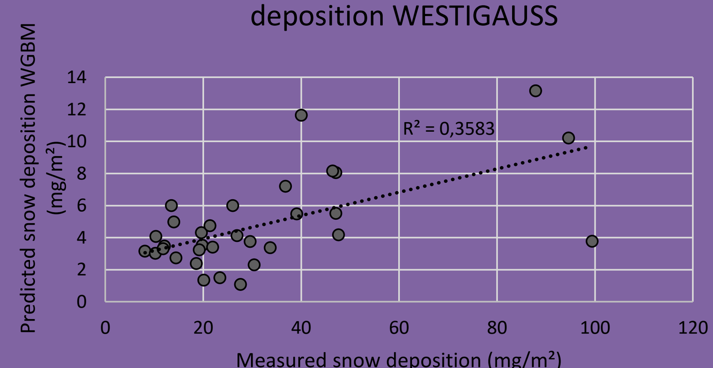

Figure 1: measured snow deposition vs. predicted deposition WESTIGAUSS Bultynck-Malet (WGBM)

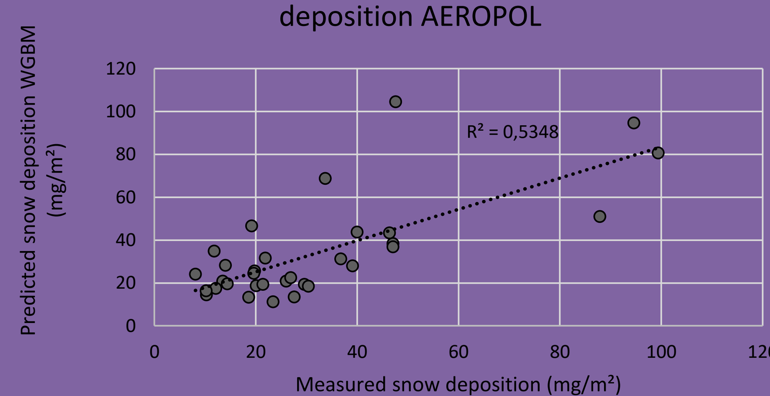

Figure 2: measured snow deposition vs. predicted deposition AEROPOL

[1] T. Vaasma, M. Kaasik, J. Loosaar, M. Kiisk and A. H. Tkaczyk, "Long-term modelling of fly ash and radionuclide emissions as well as deposition fluxes due to the operation of large oil shale-fired power plants," Elsevier, no. 178-179, pp. 232-244, 2017.

1985

As in 1971 and 1975 a centralized maximum is found at the source points as can be seen in figure 5 and 6. More variance in the lower value depositions is observed, this might be due to the overall higher deposition. The predicted maximum is 3818,70 $mg/m^2.d$ which is abnormally high, this heavily influences the mean value as can be seen by the skewness factor of 31,66. 99% of the results are below 146,29 $mg/m^2.d$ further demonstrating the maximum value is unreliable. 1985 does not continue the trend in which progressively lower deposition is expected throughout the years. Conservative dose rates were on average 4,87 $mBq/m^2.d$ and a maximum of 125,35 $mBq/m^2.d$. AEROPOL predicts a much lower maximum dose rate.

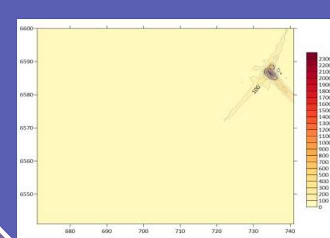

Figure 5: WGBM contour plot ('Heatmap') for the year 1985 modeling results in $mg/m^2.d$

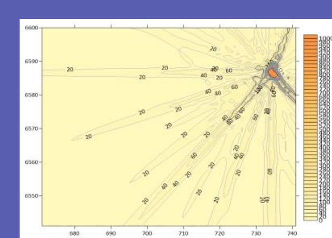

Figure 6: WGBM 'zoomed' contour plot ('Heatmap') for the year 1985 modeling results in $mg/m^2.d$

1999

Overall deposition seems to have lowered even further, further confirming the hypothesis that deposition is correlated to the emitted fly ash. A mean deposition value of 4,95 $mg/m^2.d$ and a maximum value of 298,70 $mg/m^2.d$. The WESTIGAUSS code continues to produce higher than expected maximum values, impacting the mean value. Meteorological effects could impact the model negating the 12% lower fly ash emission; however, this is unlikely as this effect is evened out by using year long meteorological data. The average and maximum dose rates were 1,01 $mBq/m^2.d$ and 71,69 $mBq/m^2.d$, This is a lot higher than the predicted AEROPOL value.

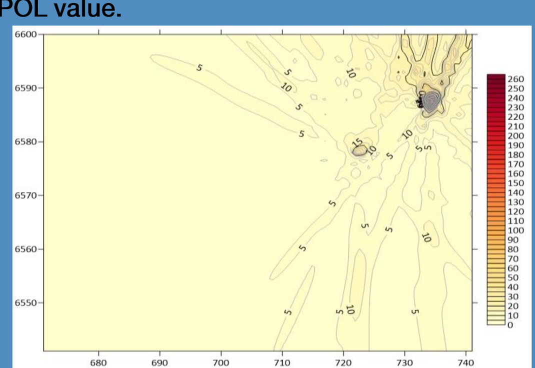

Figure 8: WGBM contour plot ('Heatmap') for the year 1999 modeling results in $mg/m^2.d$

1995

Modeling results for the year 1985 can be seen in figure 7. Overall deposition has been significantly reduced compared to the 1971, 1975 and 1985. The mean deposition value was 4,39 $mg/m^2.d$ and the maximum deposition value was 102,48 $mg/m^2.d$. This recontinues the trend set by the 1971 and 1975 results in which a steady decline in deposition is observed. The average and maximum dose rate are 0,90 $mBq/m^2.d$ and 20,91 $mBq/m^2.d$ which is very close to the predicted maximum AEROPOL deposition of aproxametly 17 $mBq/m^2.d$.

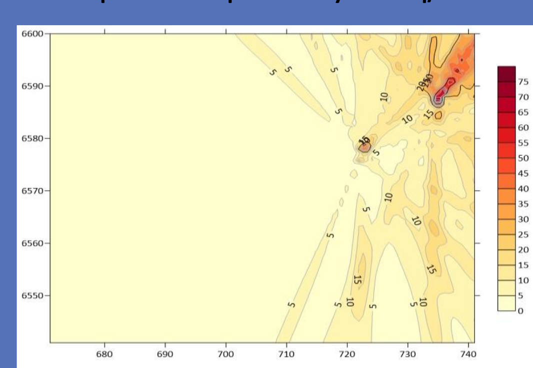

Figure 7: WGBM contour plot ('Heatmap') for the year 1995 modeling results in $mg/m^2.d$

Supervisors / Cosupervisors: Prof. Dr. Wouter Schroeyers
Dr. Tim Vidmar

SCK•CEN STUDIECENTRUM VOOR KERNENERGIE CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

UHASSELT

KU LEUVEN