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Depositions of radioactive dust in the atmosphere

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Introduction:

A monitoring post around the nuclear power plant measured ambient dose rate and rainfall until March 16, 16:44 under no power supply. The records were recovered at July 20, 2012; where, movements of radioactive isotopes in the environment, i.e., decay of the sedimentation and the energy spectrum is stored. By analyzing meanings of the records, and constructing models to simulate radioactive environment; it is an effective way to approach the truth of accident.

Theory:

The ambient dose rate is detections of radiations from grounds and sky with no-separation of the source. We try to separate them under following suppositions;

1. There are time zones that are negligible radioactive substance in the atmosphere.
2. The decay expressions in the environment can be determined for the period exactly.
3. There are observations for the rainfall in the period.

We believe in the suppositions are enable near the nuclear power plant.

We determine deposition-ratio under the conditions at first, and by using the ratio and an iterative sedimentation-equation. We separate ambient dose rate into 2 parts for ground and space. We write the deposition equation;

Bk(t+1)=exp{A(t+1)}/exp{A(t)}[Bk(t)+{Dose(t)-Bk(t)-Bg)}Dp], (1)

This is an iteration that is, Dose(t) is observed ambient dose-rate. Bk(t) is dose rate on the ground for a target plume. Bg is back-ground dose-rate caused by pre-deposition step, usually it is a constant.

Dp is a parameter, and deposition-rate, which is determined in the iteration (1).

To solve the iteration, you define a target plume, and set the start and terminal time. We write them as t_start and t_end.

Two equations,

Bk(t_start)=Dose(t_start), Bk(t_end)=Dose(t_end), (2)

are restrictions to determine the Dp.

The decay function A(t) is determined from observations of the ambient dose rate after t_end time.

We select an experimental function,

exp(At2+Bt+C), abs(A)<<abs(B), A>0, B<0. (3)

The determination constant R2 is required over 0.999.

Thus; we get an approximate ground dose rate function, {Bk(t)}, t_start<t<t_end, and Dp parameter.

We apply the approach to 4 plumes on Ohno point, {37.41N, 140.98E}. The sampling rate is 2 min.

And, we get, deposition coefficients are 1/109, 1/280~1/195, 1/21.4 for dry, rain-detection, 0.5mm-rain. Figures and details are listed in URL of reference [1].

Apprication:

Using them, as a kind of the inverse problem, we simulate the radioactive contamination in Nakadori district in Fukushima. Outline is;

1. simulated time: 3/15, 0h~3/16, 23h.
2. The atmospheric layer is 10, the maximum is 529m.
3. On each layer, the sedimentation (Sk) is fall to the ground. Relations between Sk and rainfall are;

Sk=D*Radi*(r+0.1)**0.79, D=1/280 (i.e., drizzle case at Ohno point), the exponent 0.79 is quoted from reference [2]. Bias 0.1 is a fitting parameter. The variable r is,

r=6000*r_org (r_org is RAW data of rain simulation).

Radi is a tracer-density, simulated as Cs-137. So, the ground sedimentation is got from 10 layer sum of Sks.

Thus, we get simulated dose rates for Fukushima, Koriyama, Shirakawa, Tamura-Funehiki cities,
2.93, 0.96, 1.73, 1.12 micro Sv/h. Observed ones are 2.92, 0.98, 1.41, 1.03, respectively.

Results:
We determine deposition ratio in case of rain, based on the ambient dose rate.
We simulate intensity of radioactive dose rate on Nakadori in Fukushima prefecture at the time that short-term radioisotopes are negligible and radiations from the ground become stable. It is after 15 hours from the first sedimentation. The simulations are reasonable.

Reference:
[1] Analysis of Ohno-point in Fukushima: OhnoPoint.doc
in http://suspendedparticulatematter.web.fc2.com/
[2] B. Sportisse, A review of parameterizations for modelling dry deposition and scavenging of radionuclides, Atmospheric Environment 41(2007), pp. 2683-2698.

Keywords: radioactive SPM, deposition, ambient dose rate