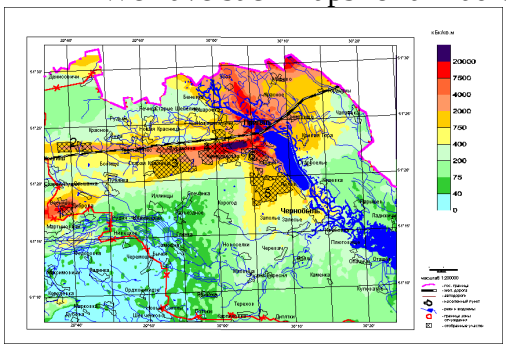
Dear Andrew,
Sergiy showed us your report on the radionuclide transfer modeling during the forest fires in the exclusion zone. In this concern, we have some questions and suggestions.

General suggestions:

1. We believe that the more accurate modeling implies the 2-D source of release, but not the point source in the centre of the 30-km ChNPP zone (at the map below we hatched the most contaminated forest stands). In practice, one can divide the forest areas into the smaller plots, for example 1x1 km^2, and consider each plot as a point source of release. We have such maps for all radionuclides.



2. The conservative estimate assumes the most critical conditions. In our case, it is the northern wind during the whole fire period, and the rather stable atmosphere (i.e. the plume direction to Kyiv), but not the uniform distribution of the wind directions during 5 days. Also, we have to model only the dry deposition of the aerosols. Of course, we can also consider the wet deposition, but in this case the plume depletion will be too fast (the radionuclides will deposit within the smaller area closer to the source of release). Besides, the 5-days rain or fog or drizzle in Kyiv only, without the same along the radioactive cloud path, is very unrealistic scenario.
3. The transfer modeling must involve calculation of the initial rise of the high-temperature plume and also must take into account the actual (or realistic) values of the parameters (such as AMAD, deposition velocity etc). We have got the experience of such calculations and experimental determination of the parameters (see attached file):
    - Yoschenko V.I., Kashparov V.A., Protsak V.P., Lundin S.M., Levchuk S.E., Kadygrib A.M., Zvarich S.I., Khomutinin Yu.V., Maloshtan I.M., Lanshin V.P., Kovtun M.V., Tschiersch J. Resuspension and redistribution of radionuclides during grassland and forest fires in the Chernobyl exclusion zone: part I. Fire experiments //*Journal of Environmental Radioactivity*, v.86, Issue 2, 2006, p.143-163)
    - Yoschenko V.I., Kashparov V.A., Levchuk S.E., Glukhovskiy A.S., Khomutinin Yu.V., Protsak V.P., Lundin S.M. and Tschiersch J. Resuspension and redistribution of radionuclides during grassland and forest fires in the Chernobyl exclusion zone: part II. Modeling the transport process //*Journal of Environmental Radioactivity*, v.87, Issue 3, 2006, p. 260-278
    - Kashparov V.A., Lundin S.M, Kadygrib A.M., Protsak V.P., Levtchuk S.E., Yoschenko V.I., Kashpur V.A., Talerko N.M. Forest fires in the territory contaminated as a result of the Chernobyl accident: radioactive aerosol resuspension and exposure of fire-fighters //*Journal of Environmental Radioiactivity*, v.51, 2000, pp.281-298.

4. Release of TUE (^{238,239,240}Pu and ^{241}Am) during the fires must be taken into account, because these radionuclides will cause the much higher inhalation doses than ^{137}Cs and ^{90}Sr. TUE activities are lower, but they are the α-emitters and thus they create the higher doses. TUE inventories in the 30-km zone are presented in our paper (attached):

- Kashparov V.A., Lundin S.M., Zvarich S.I., Yoschenko V.I., Levtchuk S.E., Khomutinin Yu.V., Maloshtan I.N., Protsak V.P. Territory contamination with the radionuclides representing the fuel component of Chernobyl fallout //*The Science of The Total Environment*, vol.317, Issues 1-3, 2003, pp. 105-119.

The total contents of radionuclides in upper 30-cm soil layer of the 30-km Chernobyl zone on 01.01.2000 (outside the ChNPP industrial site, excepting the activity located in the radioactive waste storages and in the cooling pond) made ^{90}Sr - 7.7E+14 Bq; ^{137}Cs - 2.8E+15 Bq; ^{154}Eu - 1.4E+13 Bq; ^{238}Pu - 7.2E+12 Bq; $^{239+240}$Pu - 1.5E+13 Bq; ^{241}Am - 1.8E+13 Bq.

5. Concept of Sv/e (dose calculation during only 5 days of the fire) does not match well the considered case. For inhalation (even single intake) the 50-yr effective equivalent dose is calculated, because the inhaled radionuclides can irradiate the organism during the long period, which is determined by the AMAD and solubility of the deposited aerosols and by the radionuclide metabolism in the organism. The same concerns also the external irradiation from soil and the internal irradiation from the foodstuff (of course, if people are not evacuated within 5 days. But according to the law, the decision for evacuation is taken on the basis of the expected life span dose). All these doses are easily derived from the data on the radionuclides airborne concentrations and terrestrial density of contamination – there are special coefficients for the effective dose, which take into account the radionuclides downward migration in the soil profile, radioactive decay and decrease with time of the foliar and root uptake of radionuclides by plants (and, consequently, decrease of the foodstuff contamination).
6. Contamination of the drinking water is negligible in terms of the contribution to the total dose, and it is not necessary to calculate it. Besides, Kyiv is supplied by water from the underground sources and Desna river, but not from the Kyiv reservoir.
7. Evaluation of risks from the fires (potential number of the additional cancers due to irradiation) is done on the basis of the collective dose to the whole population. Irradiation of the large population of Kyiv even in the small individual doses can give the significant collective dose.
8. The radionuclide release values during the fires must be more realistic. They can not correspond to the total inventory of the radionuclides in the 30-km zone including soil (lines 77-78 of the report). Significant part of the radionuclide activity now is associated with the mineral part of soil and will be not released during any fire. Therefore, we should consider only the activity fractions in the fuel material (vegetation and litter). In this concern, the following points may be noted: First, there are available data on the soil-to-plant transfer and vegetation contamination for all radionuclides for Chornobyl zone. Second, ^{137}Cs and ^{90}Sr transfers are different: transfer factor of ^{90}Sr is much higher. Third, the value cited in the report for ^{137}Cs transfer (13%) is overestimated. Fourth, the fuel material burn-up can be different: litter and leaves/needles can be fully burnt, but combusting of the trunks is usually lower. It is important: for instance, for ^{90}Sr the main part of activity in the aboveground biomass can be found in wood – just because of its mass, although the concentrations in wood are lower than those in needles or branches. Fifth, vegetation of the exclusion zone consists not only from the forests (mainly coniferous). We must also consider the large areas covered by grasslands and shrub, with the lower aboveground biomasses and, therefore, lower radionuclide activities in the combustible material. Thus, the release of 5% of the total radionuclide activities looks as a conservative estimate.
9. The values presented in the tables can be hardly checked: as it was already mentioned, many important parameters of the calculations were not indicated. In general, the airborne concentrations of tens Bq/m^3 at the distances ten-hundred km look rather high. It would be very interesting to know the values at the closer distances. For example, in our experiments we measured some Bq/m^3 near the source inside the area of the plume

deposition, while the fires were rather intensive (especially the grassland fires), and the burnt plots were highly contaminated.

Concerning the estimates reported

Since the report does not clarify many important input parameters of calculations (such as initial plume rise, deposition velocity, wind velocity and atmospheric stability, roughness of the surface, wet deposition rate, shape of the source etc), we can hardly evaluate the results or repeat the calculation. Thus, we have got some questions. Maybe we did not understand something.

Analysis of values of Atmospheric Discharge from Table 1 (Qi, Bq/s) and obtained values of Air Concentration from Table 2 (Ca, Bq/m^3) allow to infer that the wind direction distribution was uniform during 5 days, the height of release from the point source was 10-2000 m, the wind velocity was about 1 m/s, roughness was 0.1-1 m, deposition velocity was about 0.01m/s, and the atmosphere stability class was A-F by Pasquill. For the same parameters but for the fixed wind direction the airborne concentrations along the plume axis near the ground surface would be 10-1000 higher (depending on the stability class) at the distances reported in Table 2.

Now our remarks:

If we multiply the value of Ground Concentration (density of contamination) from Table2 (for example, $4.8*10^7$ Bq/m^2 for ^{137}Cs at the distance of 100 km) by the area of the contaminated surface within 100 km radius ($3.14*100000^2=3.14*10^{10}$ m^2), we will obtain the total activity of ^{137}Cs inside this circle. This product, $1.5*10^{18}$ Bq, is <u>three order of magnitude higher</u> than the total inventory in the 30-km zone, $1.1*10^{15}$ (Estimated Amount from Table 1; in this estimate, we even did not take into account the increase of the ^{137}Cs density of contamination with approaching to the source of release, and the territory contamination outside the 100-km zone).

Again, if we multiply a value of Air Concentration from Table 2 (for example, 10.9 Bq/m^3 for ^{137}Cs at 100 km) by the utilized value of the aerosol deposition velocity (0.01m/s) and by the period of fallout (5*24*3600=432000 s), we will receive density of contamination with ^{137}Cs, $4.7*10^4$ Bq/m^2 at 100 km, which will be three orders of magnitude lower of the same value referred as Ground Concentration in Table2, $4.8*10^7$ Bq/m^2.

These discrepancies can be explained either by **mistakes in the calculations** or by the assumed fallout patterns. For example, authors could account only for a dry deposition (or no depletion of a radioactive cloud at all) of the aerosols along the way from a source to the control points (mentioned as Distance 50, 100 and 150 km in Table 2), and then, in these points they could calculate **the wet deposition with the high velocity of about 10 m/s. <u>Usually, such cases are not considered while making prognoses</u>**. Within the frameworks of the applied Gauss model, the maximum rise of the plume is limited by the height of the temperature inverse layer – for example, this is 2000 m in summer. Therefore, if we assume the aerosol's wet deposition velocity of 10 m/s and the wind speed of 1 m/s, the aerosol will be completely washed out of atmosphere within the narrow, only 200 m wide, strip. Before this deposition area, the fallout density will be three orders of magnitude lower, and there will be no radioactive contamination at all at the bigger distances from the source. **<u>If this case was considered, it should be explicitly stated (if all the released activity deposited within the 200-m strip at the distance of 50 km, then nothing would deposit at 100 and 150 km etc)</u>**. But for this case one can not apply the dose coefficients for inhalation intake, because at the wet deposition the aerosol dispersal composition would principally differ. The same concerns the foliar contamination of plants: rain would wash off almost everything from the leave surfaces. Then the contamination

of the foodstuff (milk and meat) and the doses from the peroral intake of the radionuclides would be different. The obtained values of the terrestrial contamination density and the expected external irradiation doses within such local deposition strips imply evacuation of population from these areas according to the Ukrainian laws.

Concentration in water, expressions 2 and 3: they are either cited non-accurately, or inaccurate. For instance, in ex. 2, if we deal with the non-radioactive admixture (L=0), the concentration will be equal to the deposition velocity divided by the inflow rate. Multiplied by the lake volume, it will give the value bigger than the released amount. If the inflow is absent, the concentration will be infinite;

By our opinion, the conservative modeling must imply the planar source of release, the release value of not more than 5% of the total inventory, permanent wind direction (to Kyiv) and the dry deposition with the velocity of 0.01m/s.

Letter from: Ukrainian Institute of Agricultural Radiology, April 14, 2009