ANALYSIS OF MEASUREMENTS IN EUROPE FOLLOWING THE ACCIDENT OF CHERNOBYL NUCLEAR PLANT.

D. ROBEAU*, A. ALBERGEL**, I. WARTENBERG*

* IPSN/DPS Commissariat à l'Energie Atomique FONTENAY AUX ROSES FRANCE

** DER/SAEE Electricité de France - CHATOU - FRANCE

## INTRODUCTION

A long-range pollutant transport and deposition model, developped by Electricité de France (Aquatic and Atmospheric Evironment Department) and Meteorologie Nationale (Franch Weather Service), is used to analyse the Chernobyl radioactive plume dispersion over the European continent. Model predictions are compared to field measurements of $^{137}Cs$ activities in the air from April 26$^{th}$ to May 5$^{th}$, 1986.

## THE DATA BASE

During and following the accident on the Chernobyl Nuclear Power Plant RBMK 1000, European countries have done many measurements, either on a permanent basis used for environmental survey, or exceptionally taking into account the importance of the Chernobyl disaster.

Measurements presented in this paper have been done from April 28$^{th}$ to May 12$^{th}$ 1986. The results are concentrations of Caesium 137 in air, in term of radioactivity expressed, in Becquerel per cubic meter. Atmospheric concentration has been measured using an air pump connected to a filter retaining particles of aerosols. The period of measurement is 24 hours, generally from morning to next morning.

As regards the results of measurements done, they should be modified by the uncertainties due to : the yield of the filter, the calibration of the $\gamma$ counter, the sampling, the measurement itself.

In French laboratories, the yield of the paper filter is near 65 % if the size of particles is represented by a log-normal distribution with a mean and a standard deviation respectively of 0,3 $\mu$ m and 2 $\mu$ m. Granulometric measurements have shown that the size of measured particles is near 1 $\mu$ m, and consequently the yield of the filter can be estimated to 80 %.

The uncertainty due to $\gamma$ counter calibration is about 10 % of the value of the measurement. The uncertainty due to the measurement itself is included in 25 % to 2 % in function of the value of the radioactivity of Iodine 131. This same uncertainty concerning Caesium 137 is between 40 % and 2 %.

## II AIR MASS TRAJECTORIES

### II-a) Air Mass Trajectories

The computation of three-dimensional trajectories was accomplished using the synoptic wind field and vertical velocities obtained from the analyses of the E.C.M.W.F.

The use of vertical velocity eliminates constraints associated with the level of the trajectory (isobaric trajectories, for instance). Only the exact location and altitude of the trajectory at the starting point are required. General studies have been made to evaluate this trajectories computation (Martin et al. (1987)). It is shown that the kinematic and geographical location of air masses were improved with this method.

The computed trajectories for the Chernobyl accident provide interesting qualitative information (Strauss B. and Gros J.M. (1987)), but are not sufficient to explain all the measured data. In consideration of mean plume rise, three sets of trajectories beginning respectively at 925, 850 and 700 mb have been computed. These levels characterize the diurnal evolution of the mixing height over the emission area.

To simulate the meausrement taken ten days after the Chernobyl accident (April 26$^{th}$, 0 GMT), eighty trajectories (i.e. a new trajectory every three hours) for the three plume rise levels have been determined.

### II-b) Dispersion and Deposition

Assuming the plume centerline follows a trajectory defined by straight line segments, a Gaussian concentration field is generated, at a given time, around each segment. A plume segment is characterized by its initial polluant content and its total travel distance. The effects of material removal and plume processes are taken into account to respect the pollutant balance at each segment.

### II-c) $^{137}Cs$ Source Term

The total source term was evaluated by the USSR authorities and published at the Vienna Conference in August 1986. For the $^{137}Cs$, the value is 3.7 $10^{16}$ Bq.

The daily emission percentage were provided by the French atomic Energy Agency : 24 % on April 26$^{th}$, 8 % on April 27$^{th}$, 6,8 % on April 28$^{th}$, 5,2 % on April 29$^{th}$, 4 % on April 30$^{th}$, 4 % on May 1$^{st}$, 8 % on May 2$^{nd}$, 14 % on May 3$^{rd}$, 14 % on May 4$^{th}$, 1986.

A relation between pollutant emissions at different initial heights (925, 850 and 700 mb) was established in regard of mixing layer evolution. This evolution, determined by the radiosoundings taken, over Kiev at midday and midnight, allows to built the chronology of the initial emission on each level (925 mb, 850 mb, 700 mb).

## III - COMPARISON WITH MEASUREMENTS

As not enough dry wet deposition measurements were available, only the actual daily air activity averages are compared.

To quantify the correlation between measured data and computation results, the order of magnitude (i.e $\log_{10}$ of the $^{137}Cs$ activity) is considered.

In figure 1, measured points are plotted against computed values. Three linear regressions are drawn. The correlation coefficient is 0.57. The total number of plotted values equals 402.

The number times the model results agree, over or underestimate measurements are also counted and presented in contigency tables. The first line and the first column are reserved for values lower than $10^{-3}$ $Bq.m^{-3}$.

Table 1 shows that :

- The model underestimates the measured data in 11 % of all cases.
- The model overstimates the measured data 35 % of cases.
- The model predicts no pollution where some $^{137}Cs$ was measured in 10 % of cases. The model predicts pollution where no activity was measured 2 % of cases.

### REFERENCES

ALBERGEL, A.; MARTIN D. and STRAUSS B.
16th International Technical Meeting on Air Pollution Modeling and its Applications 6th - 10th April 1987 LINDAU.

MARTIN, D.; GRANIER, J.P.; IMBARD, M. and STRAUSS, B. (1984).
"Application of long-range transport model to a mount ETNA plume" Bull. Volcanol. vol 474(2-184) pp 1097-1106.

MARTIN, D; MITHIEUX, C. and STRAUSS, D. (1987).
"On the use of the synoptic vertical wind component in a transport trajectory model" Atmospheric Environment Vol. 21, N° 1, pp 45-52.

ROBEAU, D. and WARTENBERG I. (1987).
"Measurements of radioactivity in Europe during and following the accident of the Chernobyl Nuclear Power Plant" Post Chernobyl Workshop 3rd - 5th February 1987 BRUSSELS.

STRAUSS, B. and GROS, J.M. (1987).
"Information sur l'accident de TCHERNOBYL".
La Météorologie N° 15 pp 14-15.

TABLE I : EUROPE (10°W, 40°E, 35°N, 65°N)

| | Am <-3 | -3≤Am<-2 | -2≤Am≤-1 | -1≤Am<0 | 0≤Am<1 | 1<=Am<2 | 2<=Am<3 | |
|---|---|---|---|---|---|---|---|---|
| Ac<-3 | 17 | 3 | 18 | 33 | 22 | 0 | 1 | 94 |
| -3≤Ac<-2 | 2 | 0 | 0 | 1 | 3 | 0 | 0 | 6 |
| -2≤Ac<-1 | 4 | 0 | 6 | 9 | 14 | 0 | 0 | 33 |
| -1≤Ac<0 | 1 | 0 | 6 | 5 | 35 | 1 | 0 | 48 |
| 0≤Ac<1 | 1 | 1 | 2 | 25 | 188 | 4 | 0 | 221 |
| 1≤Ac<2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2≤Ac<3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 25 | 4 | 32 | 73 | 262 | 5 | 1 | 402 |

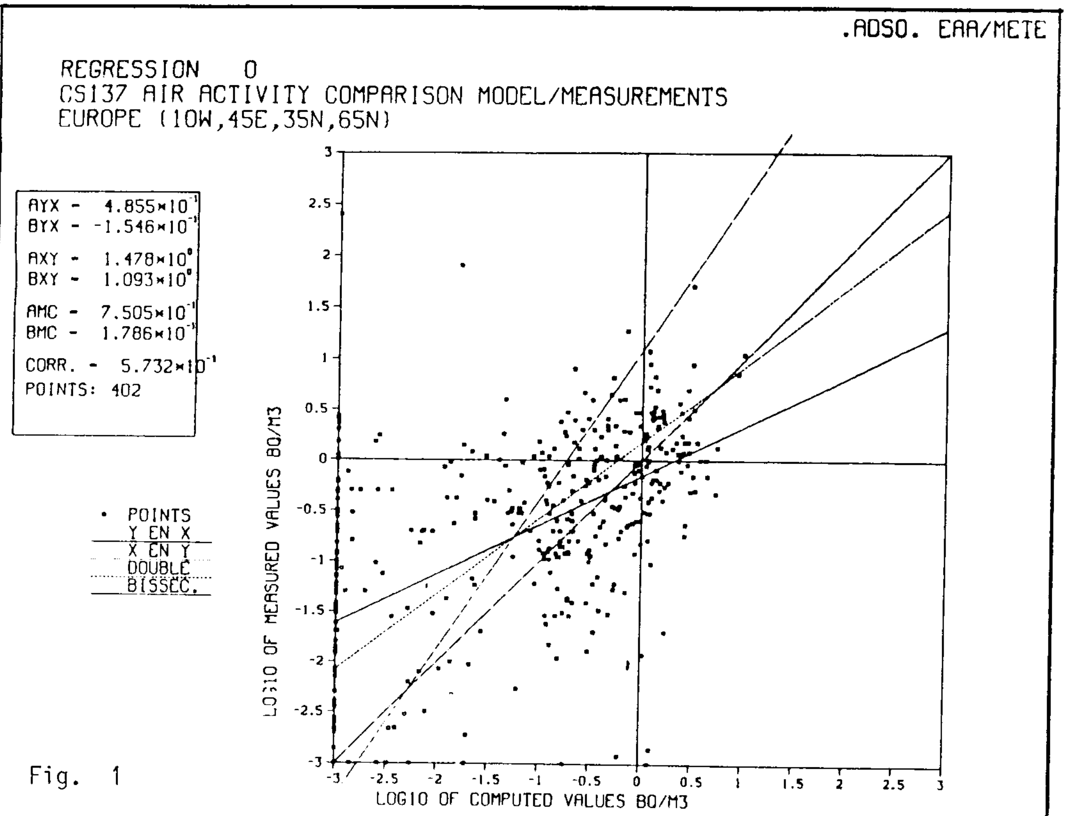


Fig. 1