2.4 NUMERICAL SIMULATION OF LONG DISTANCE TRANSPORT OF POLLUTANTS OF ENVIRONMENTAL EMERGENCY RESPONSE ACTIVITY AT QINSHAN NUCLEAR POWER PLANT

Tan Jiqing Zhang Zhiying
(Institution of Meteorological Information and Prediction of Disaster Events,
Zhejiang University, Hangzhou, P.R. China 310027)

1. INTRODUCTION

The first nuclear power station was built at USSR in 1954, and there have been 432 nuclear power stations in the world until in 1994, which take one sixth of the total electricity capacity in the world.

Although the probability of accidents for nuclear power plants is very low, but the two major accidents in the history of civil nuclear power generation made scientists to take consideration of safety problem for nuclear power plants.

Qinshan nuclear power plant is one of the two nuclear power plants in China and it is located in the special economic zone called “Chang Jiang delta area “. Previous work have been done to answer the question “Within how wide of the region nearby would the air quality be affected at dangerous level if a small accident occurs at Qinshan nuclear power plant?”.

In this paper, we first discuss why the large scale movement for pollutant is quite different from small scale movement for pollutants. And then we employ a long distance transport model to simulate 168 cases. After averaging the concentration fields according to the classification of weather situation

2. Large scale transport process and Small scale diffusion

As we know, if the concentration field of a pollutant is $C(x, y, p.t)$, $S(x, y, p, t)$ and $D(x, y, p, t)$ are the source item and deposition item， and the component of the wind in X and Y direction is u , v and ω , then the mass conservation law can be written as in the p coordinate:

$$\frac{\partial C}{\partial t} + u\frac{\partial C}{\partial x} + v\frac{\partial C}{\partial y} + \omega\frac{\partial C}{\partial p} = S + D \qquad (1)$$

In order to identify the Large scale transport process and Small scale diffusion process，we suppose that there exist a small parameter ε （ ε <1 ） and let $C(x, y, p.t)$, $S(x, y, p, t)$, $D(x, y, p, t)$, u , v and ω be the function of ε as following:

$$C = C_0 + \varepsilon C_1 + \varepsilon^2 C_2 + \dots$$

$$u = u_0 + \varepsilon u_1 + \varepsilon^2 u_2 + \dots$$

$$v = v_0 + \varepsilon v_1 + \varepsilon^2 v_2 + \dots$$

$$\omega = \omega_0 + \varepsilon \omega_1 + \varepsilon^2 \omega_2 + \dots \qquad (2)$$

$$S = S_0 + \varepsilon S_1 + \varepsilon^2 S_2 + \dots$$

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* Corresponding author address: Tan Jiqing, Institution of Meteorological Information and Prediction of Disaster Events, Zhejiang University, Hangzhou, P.R. China 310027
email: Tan_jiqing@126.com

$$D = D_0 + \varepsilon D_1 + \varepsilon^2 S D_2 + \dots$$

put all of the equation above-listed into (1), use WKB method, we obtained:

$$\frac{\partial C_0}{\partial t} + u_0 \frac{\partial C_0}{\partial x} + v_0 \frac{\partial C_0}{\partial y} + \omega_0 \frac{\partial C_0}{\partial p} = S_0 + D_0 \quad (3)$$

$$\frac{\partial C_1}{\partial t} + u_0 \frac{\partial C_1}{\partial x} + u_1 \frac{\partial C_0}{\partial x} + v_0 \frac{\partial C_1}{\partial y} + v_1 \frac{\partial C_0}{\partial y} + \omega_0 \frac{\partial C_1}{\partial p} + \omega_1 \frac{\partial C_0}{\partial p} = S_1 + D_1 \quad (4)$$

$$\frac{\partial C_2}{\partial t} + u_0 \frac{\partial C_2}{\partial x} + u_1 \frac{\partial C_1}{\partial x} + u_2 \frac{\partial C_0}{\partial x} + v_0 \frac{\partial C_2}{\partial y} + v_1 \frac{\partial C_1}{\partial y} + v_2 \frac{\partial C_0}{\partial y} + \omega_0 \frac{\partial C_2}{\partial p} + \omega_1 \frac{\partial C_1}{\partial p} + \omega_2 \frac{\partial C_0}{\partial p} = S_2 + D_2 \quad (5)$$

From （3）， (4）and （5）, we know that:

C_0 is determined by u_0, v_0 and ω_0 which is wind part stand fo large scale of movement of surrounding air， and the S_0 and D_0. Therefore, it means that if we only focus on simulating the concentration field C_0 caused by large scale transport process, the large scale wind by surrounding air and the large scale source S_0 and deposition field D_0 will be the main calculation item.

C_1 is determined not only by u_0, v_0 and ω_0 which is wind part stand for large scale of movement of surrounding air，but also determined not only by u_1, v_1 and ω_1 which is wind part stand for small scale of movement of surrounding air and the S_1 and D_1. Therefore, it means that if we only focus on simulating the concentration field C_1 caused by random dispersion process, it would be more complicated than the transporting process.(

In a word, if our purpose is to simulate a dispersion phenomenon caused by at the level of small accidents within the affected area about less than 10 km, we had better use a puff model or so. If we take consideration of an accident at the level of Chernobyl, we should use a long distance transporting model.

3. SOME NUMERICAL EXPERIMENT RESULTS BY RUNNING THE HYSPLIT-4 MODEL，NOAA，USA

With the Standards for default parameters on EER for initial run by the HYSPLIT-4，which is the model of Air Resource Lab，NOAA，USA , 168 cases

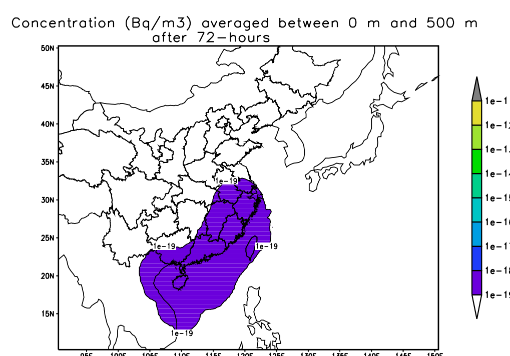

Figure 1

have been simulated. These cases have been selected from the ten–year reanalysis meteorological data of NCEP , from 1992 to 2001 by focusing on whether those weather situation patterns may affect mainland China or not. After

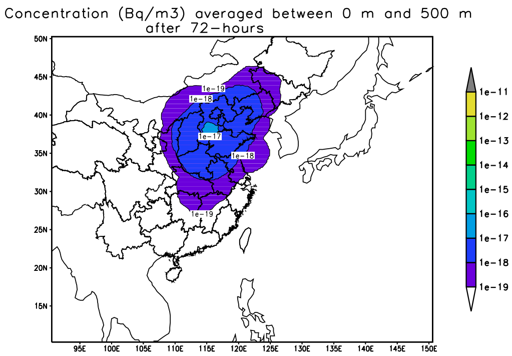

Figure 2

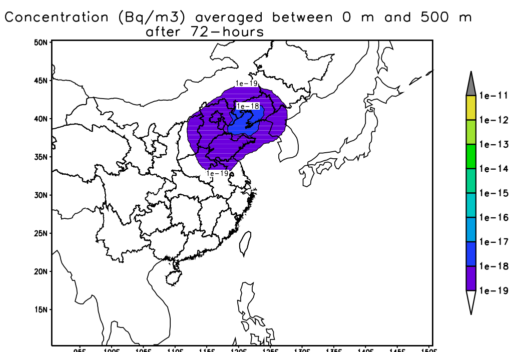

Figure 3

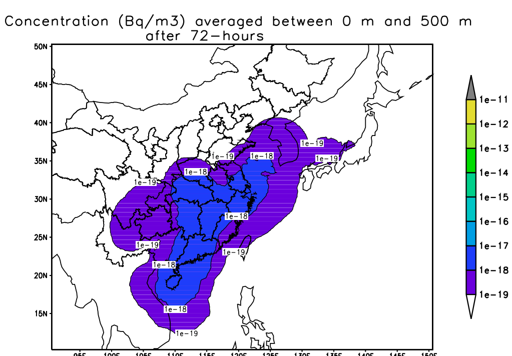

Figure 4

averaging the modelling data at the same region at different seasons, we obtaining the following results.

Qinshan nuclear power plant is located at Chang Jiang Delta (CJD) area. Because CJD is both the highest developed economic zone in China and the highest population density zone in China, the safety problem for Qinshan nuclear power plant becomes more and more urgent. The economy of China would be destroyed if such a big nuclear accidents like Chernobyl would happen in Qinshan. Therefore, in this paper, we focus on this scientific problem “Averaging speaking, how and where the radioactive hazard material from the Qinshan would be transported to affect the air quality there on different seasons, if a big accident at the level of Chernobyl would happen in Qinshan”. This is very important question for our government to make some accident rescue plan patterns change a lot from season to season. Because of uncertainty for the source, etc, it would be helpful if we can understand the average situation for many similar weather situation patterns. Here we show the results basing on running Hysplit-4 model for 168 cases with the data selected ten-year meteorological data of NCEP ,USA, from 1992 to 2001, and to use Hysplit-4 model with the standard default source parameters for the initial run case by case to output 72 hours simulation concentration fields. After averaging the 72 hours simulation concentration fields case by case in same season we obtain four averaged concentration fields showing in Figure 1 to Figure 4, which are the averaged concentration fields in winter, spring, summer and autumn.

From these figures, we could see that the most dangerous season is if a big accident at the level of

Chernobyl accident because the contaminated area is the largest and the concentration density is the strongest. The winter season is the least dangerous season because the concentration density is the weakest and many contaminated area is locates over sea area while the autumn season is the most dangerous season. The spring and summer seasons are separately at the second and the third place dangerous seasons.

5. CONCLUSION

In this paper, at first, we use WKB method to derive the relationship between the large scale long distance transport process and short distance dispersion process. Using the first order formula for small parameter ε , we found that for big accident like what happen in Chernobyl Nuclear Power Plant in April,1986, we could only use long distance transport model like Hysplit-4 model to simulate the large scale feature and the simulated concentration field in 72 hours can be used to evaluate the affected areas for us to make rescue emergency plans for inhabitants near the Qinshan nuclear power plan .

Secondly, after several paragraphs to outline the Hysplit-4 model, we employed the model on the base of ten-year Re-analysis data of NOAA, USA, to simulate the concentration fields case by case in 72 hours. After averaging the 72 hours concentration field for those in the same season, we know that the winter season is the least dangerous season because the concentration density is the weakest and many contaminated areas are located over the sea area while the autumn season is the most dangerous season because the concentration density is the strongest than those in other seasons and many contaminated areas cover more than 10 provinces of China and even including areas of Korea and Japan sea. The spring and the summer seasons are separately the second and third most dangerous seasons.

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