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The Study on the Ranks of Environment Emergency Response Activity Based on Weather Patterns

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Abstract

Ever since the first nuclear power plant called Obninsky plant was established on June 27, in 1954, more than 300 accidents have taken place in the past nearly sixty years. Recently, after the accident of fukushima nuclear power plant, in Japan, occurred on March 11, 2011, the safety problem for nuclear power plant becomes one of the most important issue which the leaders of governments in the world should take full consideration of. Levels of the ranks of nuclear accidents have been defined after the major accidents have occurred. However, the forecasting service for environment emergency response (EER) activity by WMO should be submitted before and during a nuclear accident. Therefore, the ranks of EER should be defined due to the requirement of the local governments of the government for an accident. Here we show some study on a real EER service for a nuclear accident in Japan, on September 30, 1999 on Beijing Center for EER, CMA. Consciousness of some scientific problems of the numerical simulation of EER, the ranks of EER acitivity has also been suggested.

Keywords: Environment Emergency Response; Nuclear Power Plant; Nuclear Accident

1 INTRODUCTION



FIGURE 1 EER PRODUCT OF RMS BEIJING

The proablility of nuclear accidents of nuclear power plants had been exaggeratively considered to be extremely low by the nuclear industry international groups which promote nuclear power plant construction. The nuclear safety plan of nuclear power plants is thus limited only within the scope of in site and off site rescue plans which are plans in 10 kilometers. However, after more than 300 accidents of nuclear power plant emergency in the past sixty years, environment emergency response (EER) plans by WMO aimming at impact areas from 100 square kilometers to more than 1,000 thousands square kilometers have been taken into consideration with establishing more than eight official EER centers. Beijing EER center is one of them. During the period from 1996 to 1999, a long distance transporting model called LMTTP-2 model, designed by the author of this paper, provided EER products based on the on-line meteorological fields from T106 model, NMC, CMA. On September 30, a nuclear accident occurred in the nuclear power plant called Tokaimura.

The other seven EER submitted their EER products which indicated that they would be a large-scale contamined area by radio-active pollutants which can cover most aera of the main island of Japan excepted for EER products from EER Beijing. The EER products by LMTTP-2 in EER Beijing indicated that the concen-tration field of radioactive pollutants would cover a little part of the main island of Japan (see Figure 1). The government of Japan trusted the EER products of Beijing, and no measures had taken to evacuate large population of people nearby. Therefore, it is very important to make definition of ranks of EER based on weather patterns of over the accident

spots, otherwise, the economic loss would be larger than the nuclear accidents itself which belong to small-scale EER. Of couse, the success of this EER by Beijing was benefited from the LTMMP-2 model was on-line coupled with the PBL scheme of T106,which provided more information of wind fields of boundary layers while other EER products of other seven EER centers used the off-line meteorological data of their medium-range forecasting models in their own national meteorological centers'.

2 Levels of Accidents of Nuclear Power Plants and RanKs of EER

2.1 Levels of Accidents of Nuclear Power Plants

There are seven levels for the accidents according to the user's manual of the International Nuclear and Radioactive Event Scale (INES) of IAEA. According to the mannual, events from level 1 to level 3 are called incidents, and events from Level 4-7 are called "accidents". Information of Level 7 accidents mean major accidents which impact on people and environment and radio-active materials have been released with widespread health and environmental effects requiring implementation of planned EER activity. For axample, the Chernobyl disaster occured on 26 April 1986, which leaded to a powerful steam explosion and fire that released a significant fraction of core material into the environment, resulting in a death toll of 56 as well as estimated 4,000 additional cancer fatalities among people exposed to elevated doses of radiation. As a result, the city of Chernobyl was largely abandoned, the larger city of Pripyat was completely abandoned, and a permanent 30 km exclusion zone around the reactor was established. Fukushima on 11 March 2011. In this accident, major damage to the backup power and containment systems caused by the 2011 Tōhoku earthquake and resulted in overheating and leaking from some nuclear plant's reactors. A temporary exclusion zone of 20 km was established around the plant as well as a 30 km voluntary evacuation zone; in addition, the evacuation of Tokyo – Japan's capital and the world's most populous metropolitan area, 225 km away.

Level 6 accidents mean serious accidents impact on people and environment while significant release of radioactive material is likely to require implementation of planned EER activity. For example, the Kyshtym disaster occurred on 29 September 1957 at Mayak, Soviet Union, which a failed cooling system at a military nuclear waste reprocessing facility caused a steam explosion that released 70–80 tons of highly radioactive material into the environment, and impact was limitted on local population. The accident is lower than level 7 accidents but it dosn't mean that it need only smalller-scale of EER activity. Level 5 accidents mean wider consequences of radioactive material release and several deaths show us that the accident would be likely to become worser, therefore, it might require more activity to protect the residents surround the accident spot. For example, Windscale fire on 10 October 1957 in United Kingdom, which annealing of graphite moderator at a military air-cooled reactor caused the graphite and the metallic uranium fuel to catch fire, releasing radioactive pile material as dust into the environment. Another accisent called Three Mile Island accident near Harrisburg, Pennsylvania (United States), on 28 March 1979 also belong to this level. Level 4 accidents mean minor release of radioactive material already cause at least one death. This kind of accidents would become worse and the environment had been impacted slightly. For example, Tokaimura nuclear accident (Japan) on September 30, 1999 which three inexperienced operators at a reprocessing facility caused a criticality accident; two of them died, and minor dose of radioactive materials entered the atmosphere. Incidents below level 3, which belong to the scope of on-site emergency plan and off-site emergency plan, are not disscussed here in this paper.

2.2 Ranks of EER Based on the Weather Patterns over the Accidents' Spot

EER activity is established on the purpose of evacuation of residents beyond the scope of on-site emergency plan and off-site emergency plan. Due to the risk of the large amount of economic loss for the wrong decision of the evaculation activity for an accident, more accurate information of EER products provided by official EER centers should be seriously taken into consideration. There are at least two aspects of scientific problems should be mostly concearned of. One is the predictability of meteorlogical models, and the other is the uncertainty of diffusion and transport models of hazard materials. During the expertising group meeting on EER at Viena in December, 1997, Roland Draxler advocated to use ensemble EER products of different meteorological fields provided with different sources. For example, using ensemble EER products from different initial fields from different models or from one

meteorological model but with different initial time. Iwasaki, Japanese experts advocated to pay more attention on the uncertainty of diffusion and transporting models.

All these years for our research group work on the two aspects.

On the first aspects of scientific problems, we focus on understanding of routines and concentration levels under different weather patterns. For example, Tan et al, 2006; Tan (2010; 2011) simulated 182 cases under different weather patterns for Qinshan nuclear power plant if level 7 accident occurs in future. Four kinds of routines were obtained .On the second aspects of scientific problems, we focus on solving minus value (MV) problem (Tan and Masaru, 2000, 2001, 2002), and advection scheme (Tan and Masaru, 2001) for transporting models and non-uniform Continuiry problems (Tan et al, 2011).With these progresses, we put forward here about the opinion of ranks of EER according to the weather patterns over the accident spot.

There should be three kinds of EER ranks according to the horizontal scale of weather patterns. The first is large-scale EER activities which ralative safety area for citizens would be more than 100km away from the accident spots. For example, in the level 7 accident called Chernobyl cause the city of Chernobyl was largely abandoned, and the larger city of Pripyat was completely abandoned. Furthermore, a permanent 30 km exclusion zone around the reactor was established.

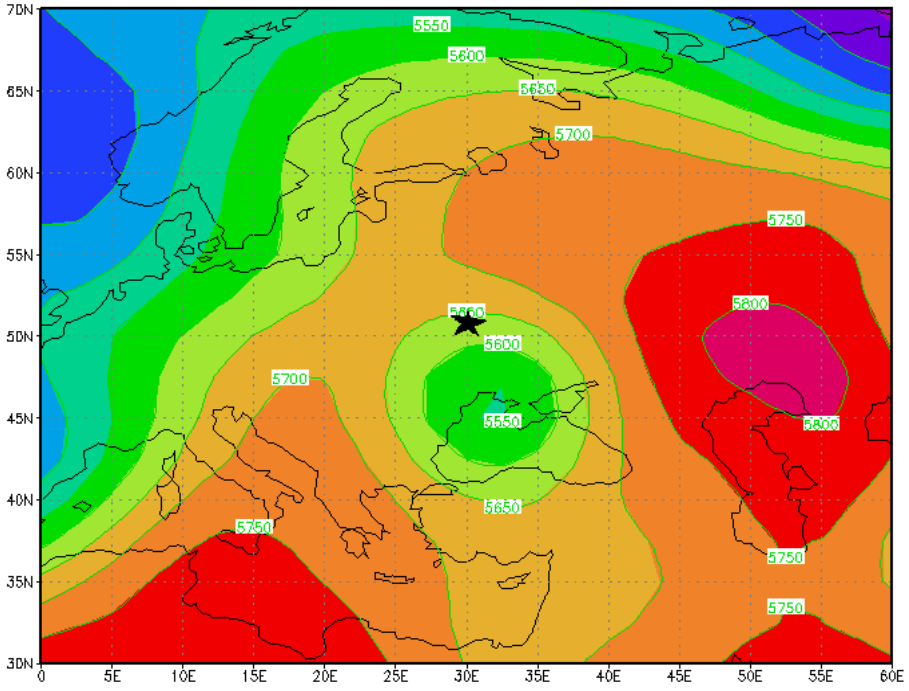


FIGURE 2 THE GEOPOTENTIAL HEIGHT FIELD AT 500 HPA ON APRIL, 26, 1986

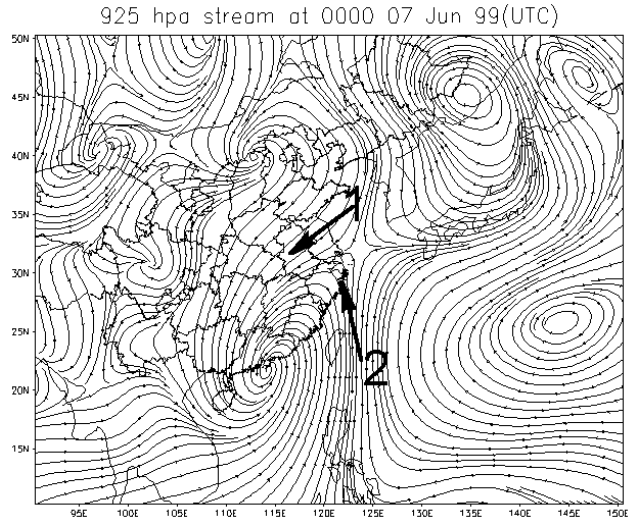
From figure 2, the nuclear power plant is located at the north part of a cutoff low, which make radioactive materials to be transported to upstream area in the middle of the atmosphere and radioactive materials had also been transported to the downstream area in the lower atmosphere due to the opposite sub-circulation for this pattern.

The second is middle-scale EER activities, which the least relative safety distance from the spot for citizens would be in the range from 30 km to 100km away from the accident spots. For example, the Fukushima Daiichi nuclear disaster was a series of equipment failures, nuclear meltdowns and releases of radioactive materials on 11 March 2011. Although it is the second largest nuclear disaster in the world. Concerns about the atmospheric venting of radioactive gasses led to a 20 km (12 mi)-radius evacuation around the plant, but the Japanese government affirm that the radioactive dose of casium-137 be safety during the 30—50km from the plant based on the measurement data of ground and ocean.

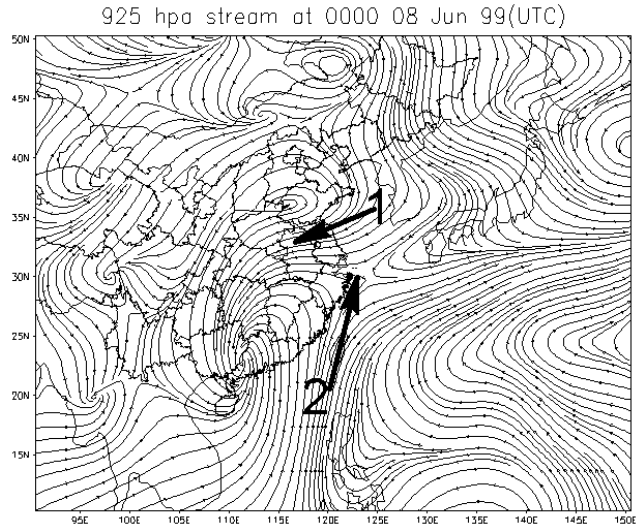
The third is small-scale EER activities, which the least safty area for citizens would be shorter than 30km. For example, The Tokaimura nuclear accident indicates the nuclear disaster which occurred on 30 September 1999,

resulted in two deaths. It was the worst civilian nuclear radiation accident in Japan prior to the Fukushima Daiichi nuclear disaster of 2011.The criticality accident occurred in a uranium reprocessing facility, a subsidiary of Sumitomo Metal Mining Co. in the village of Tōkai, Naka District, Ibaraki Prefecture. The accident occurred as three workers were preparing a small batch of fuel for the fast breeder reactor, using uranium enriched to 18.8% with the fissile radionuclide known as U‑235 . At around 10:35 a.m., a precipitation tank reached critical mass when its fill level, containing about 16 kilograms of uranium, reached about 40 liters.

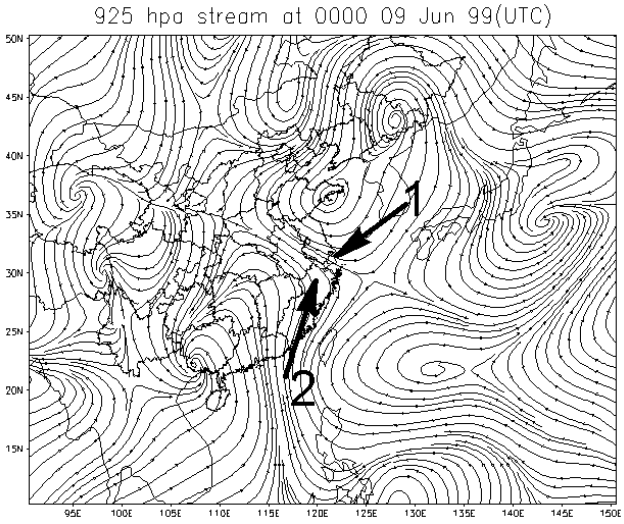
3 COMPARISON STUDY BETWEEN THE TWO DIFFERENT WEATHER SYSTEM PATTERNS



(a) on June 7,1999GMT0000



(b) on June 8,1999GMT0000



(c) on June 9,1999GMT0000

FIGURE 3 FLOW-LINE MAPS ON 925 HPA

3.1 A Case Study During the Meiyu Season in 1999

Figure 3a,b&c are the flow-line maps on 925 hPa from June 7 to June 9,1999. Supposing that a level 7 accident occurred at Qinshan nuclear power plant on June 7, 1999 under this weather pattern: arrow no:1 stands for north-eastern wind while arrow 2 stands for south wind.

3.2 Numerical Simulation Fields of Radio-active Materials for A Meiyu Case

In order to make this study more objective to show the evidences, we employ Hysplit4, which is the model of Air

Resource Laboratary (ARL), NOAA, USA, to simulate the transporting processes in three days.

Figure 4a,b,c,d &e are the forecasting map of the concentration fields near surface from June 7 to June 9,1999.

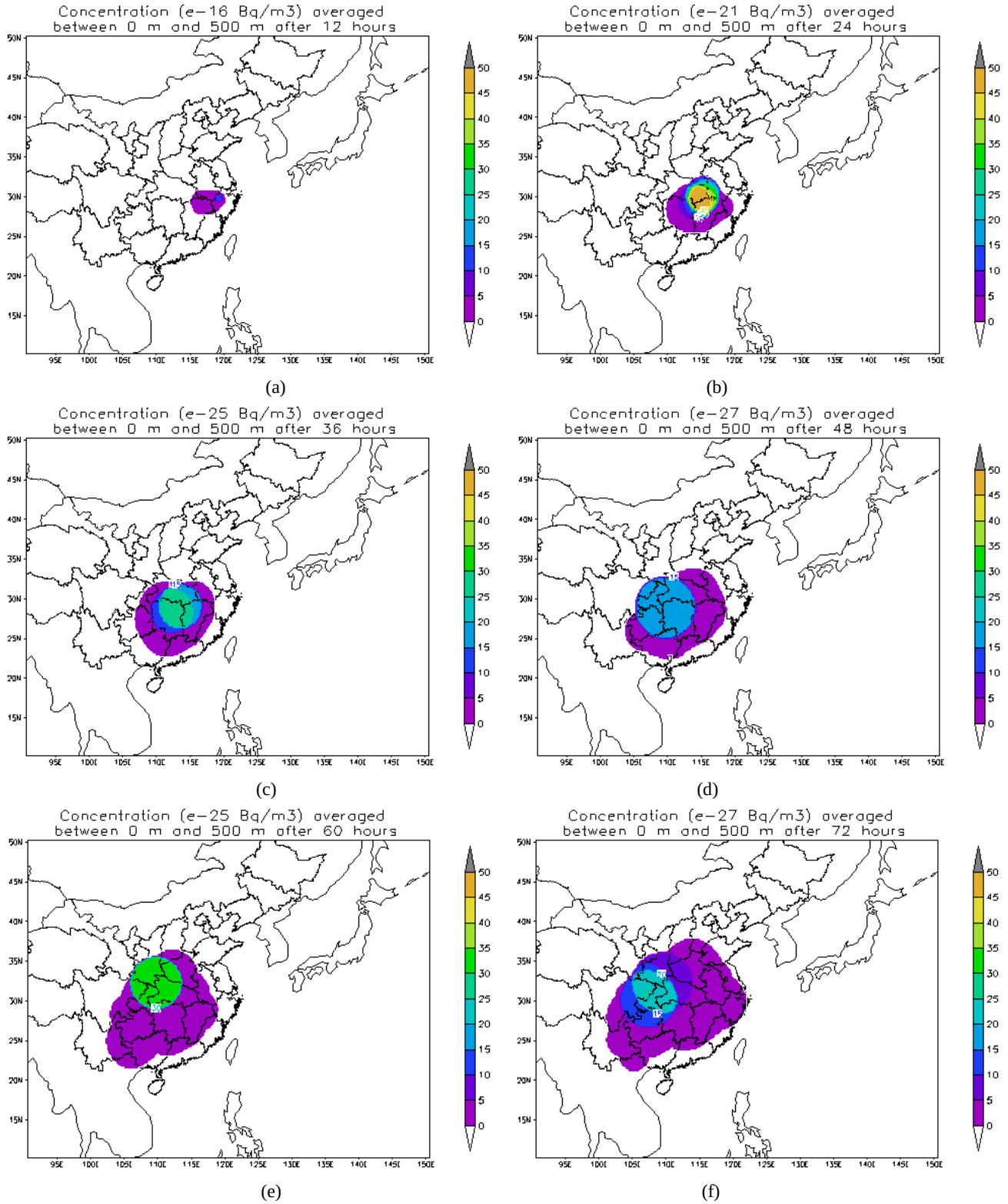
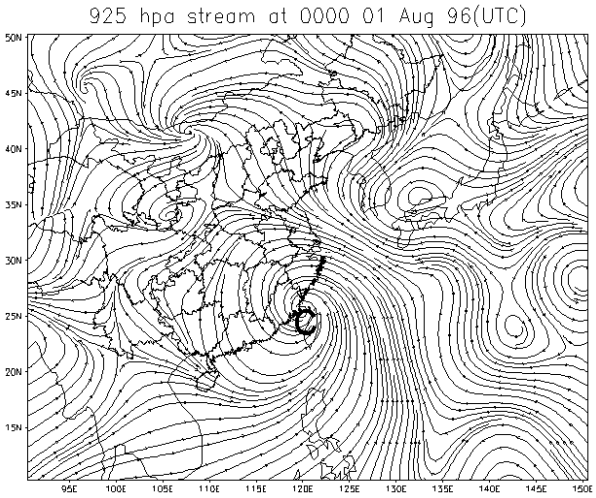


FIGURE 4 NUMERICAL SIMULATION FIELDS OF CONCENTRATION FIELDS AVERAGED BETWEEN 0M TO 500 M AFTER DIFFERENT TIME: (A) 12 HOURS (B) 24 HOURS (C) 36 HOURS (D) 48 HOURS (E) 60 HOURS (F) 72 HOURS

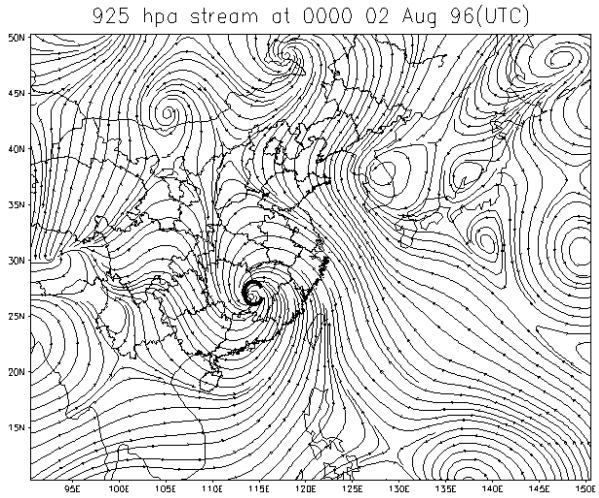
3.3 A Case Study During the Typhoon Season in 1996

Figure 5 a, b & c is the flow-line maps on 925 hPa from August 1 to August 3, 1996. Supposing that a level 7

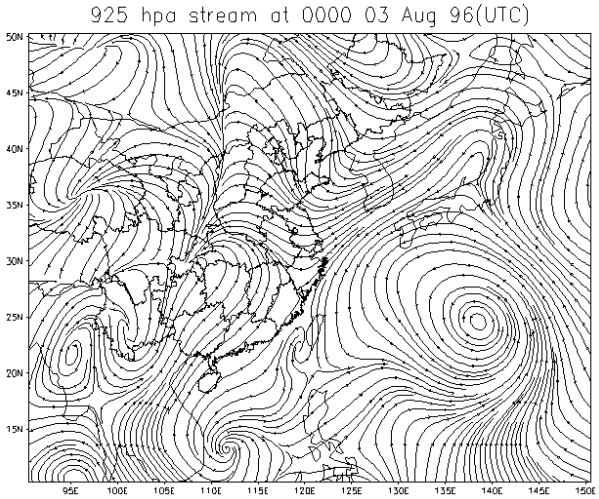
accident occurred on August, 1996 under this weather pattern:



(a) on August 1,1996GMT0000



(b) on August 2,1996GMT0000

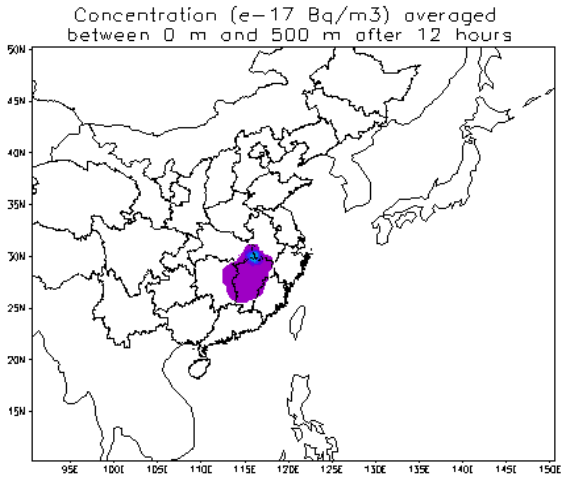


(c) on August 3,1996GM0000

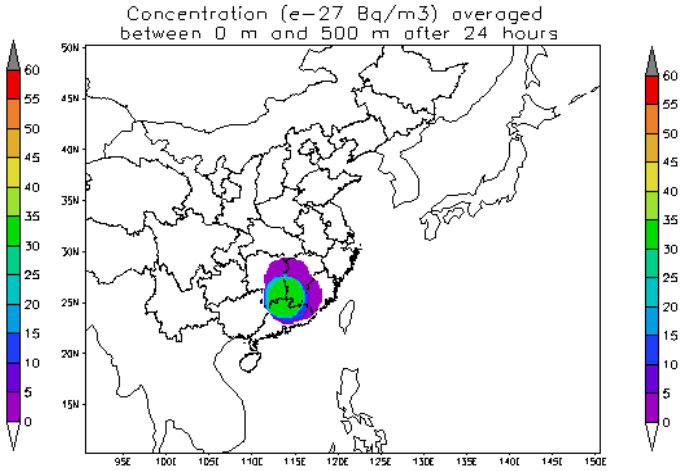
FIGURE 5 FLOW-LINE MAPS ON 925 HPA

3.4 Numerical Simulation Fields of Radio-active Materials for A Typhoon Case

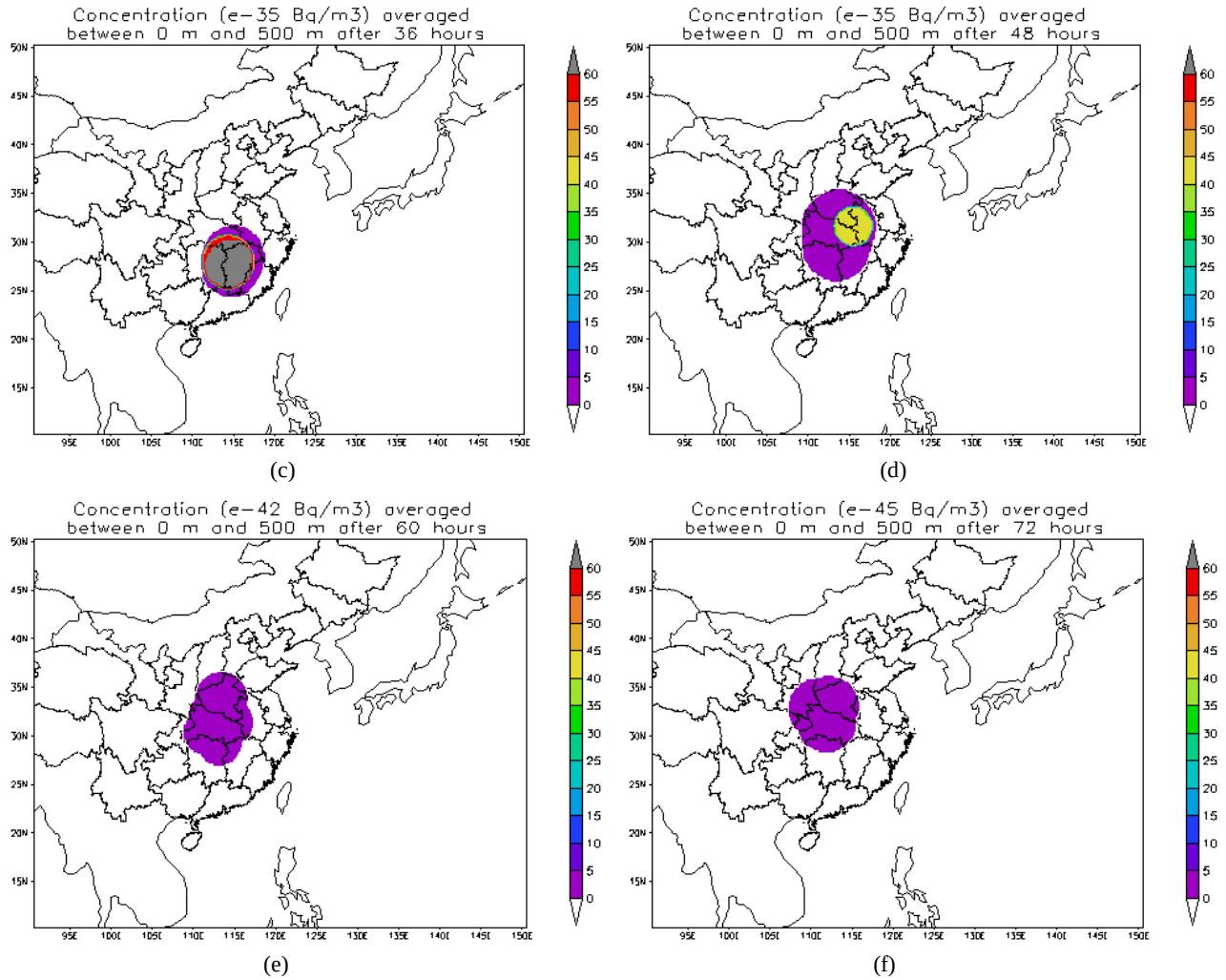
Figure 5a,b,c,d &e are the forecasting map of the concentration fields near surface from August 1 to June 3,1996.



(a)



(b)



(c) (d)

(e) (f)

FIGURE 5 NUMERICAL SIMULATION FIELDS OF CONCENTRATION FIELDS AVERAGED BETWEEN 0M TO 500 M AFTER DIFFERENT TIME: (A) 12 HOURS (B) 24 HOURS (C) 36 HOURS (D) 48 HOURS (E) 60 HOURS (F) 72 HOURS

4 CONCLUSIONS

In this paper, we put forward the three types of EER activities according to what the weather pattern is over the accident spots. In order to prove this, two case studies have been done supposing that level 7 accidents would occurred in June 7 to June 9,1999 or in August 1 to Agust 3,1996. And the numerical simulation of concentration fields indicate that the affected area are different. The affacted area of typhoon case would be smaller than the affected area of Meiyu case.

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He has been the chairman of three projects supported by National Natural Science Foundation of China, the granted numbers are: (40345025; 40475043&40875091)