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THREAT TO TURKEY FROM POTENTIAL ACCIDENTS AT THE SOVIET-DESIGNED METSAMOR NUCLEAR POWER PLANT, ARMENIA: TRACER AND TRAJECTORY ANALYSES AND EPISODE STUDIES

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ABSTRACT

After the Chernobyl accident, several European countries were affected by large and highly radioactive particles. In the Chernobyl accident most of the particulate material was deposited within 20 km of the plant, but about one-third was transported even thousands of kilometers. There is no doubt that at a relative remote distance from the accident site, the Turkish territory was affected by depositions and high concentrations of radioactive pollutants released to the atmosphere during the accident. In contrast, Turkish authorities have not been concerned sufficiently about the different aspects of safety at nuclear installations in the former Soviet Union.

The Metsamor nuclear power plant in Eastern Armenia is the closest (16 km) Russian-designed nuclear power plant to Turkey. One of the main concerns regarding nuclear power plants is the possibility of accidents. In addition to old technologies and unsatisfactory safety measures, the location of the power plant exposed to severe seismic waves gives a high possibility of accidents. The estimation of the probability that air in the Metsamor region would be transported to Turkey following a hypothetical accident has been used in the MM5 tracer and trajectory model.

Key Words: Trajectory Analysis, Criteria for Worst Case, Nuclear Accidents, Travel Time Statistics

1. INTRODUCTION

The Chernobyl Nuclear Plant Accident, which occurred in 1986, has unfortunately not been the center of concern in Turkey. Recently, because of the increasing number of cancer diseases in Northern Turkey which was the most affected area of Turkey from the accident, his has become a current issue. Actually, even today, scientists in many countries are still interested in the problem concerning the consequences of the accident in affected areas, primarily related to the state of the health of today's and future generations. The results of Fesenko et al. (2005) study showed that in the early period after the Chernobyl accident for many biota species (primarily for terrestrial flora and fauna) in the most affected areas, an excess of irradiation over the critical levels has been observed. On the other hand, after the Chernobyl accident, several European countries were affected by large and highly radioactive particles (Pöllanen et al., 1997). In the Chernobyl accident most of the particulate material was deposited within 20 km of the plant, but about one-third was transported even thousands of kilometers (Powers et al., 1987).

During the Chernobyl accident, a large quantity of radionuclide was released into the troposphere, transported partially over long distances and it contaminated a wide geographical area (Tschiersch and Georgi, 1987; IAEA, 1991). Even though the Turkish territory was thought to be at a safe distance from the site of the accident, it was affected by large depositions and high concentrations of radioactive pollutants released to the atmosphere during the accident (e.g. Pöllanen et al., 1997; Langner et al., 1998). A similar hazard could be faced in the near future and this time could pose a more dangerous threat for Turkey. The Metsamor nuclear power plant in Eastern Armenia is the closest (16 km) Russian-designed nuclear power plant to Turkey (Figure1). One of the main concerns regarding nuclear power plants is the possibility of accidents. In addition to old technologies and unsatisfactory safety measures, the location of the power plant exposed to severe seismic waves gives a high possibility of accidents.

Figure 1. The location of Metsamor Nuclear Power Plant and some big cities of Turkey near Metsamor.

The European Union will allocate 100 million Euros to Armenia for bringing the Metsamor Nuclear Power Plant to a halt and searching for new energy sources. However, the grant was frozen and will not be allotted unless the Armenian government announces the precise term to close down the plant. The Armenian government declares that some 800 million Euro is necessary to close the Metsamor and for other relevant arrangements, as well as for developing alternative energy systems (ArmeniaNow.com, 2004).

Our aim here is to show the scale of the approaching hazard and to fix Turkish territories which could be possibly affected.

2. METHODOLOGY

The estimation of the probability that air in the Metsamor region would be transported to Turkey following a hypothetical accident has been used in the MM5 tracer model. This on-line approach avoids temporal interpolation errors that can inherently limit the accuracy of more commonly used off-line calculations of pollutant transport and diffusion.

Fifth-Generation NCAR / Penn State Mesoscale Model (MM5; Grell et al. 1994) V3.6, on-line tracer model (MM5T) was used here. A single domain with grid-spacing of 9 km is configured, and it covers the entire Turkey and the Caspian Sea. There are 200 x 300 x 23 grids in the east-west, north-south, and vertical directions, respectively. Tracers in MM5T are carried in a 4D array and the transport of tracers due to advection, MRF boundary layer mixing (Hong and Pan 1996), and Kain-Fritsch cumulus convection (Kain 2004) is taken into account. Other chosen physics options are the RRTM (Rapid Radiative Transfer Model) radiation scheme (Mlawer et al. 1997) and simple ice microphysics scheme (Dudhia 1989).

On the other hand, a hypothetical accident has been studied with the trajectory approach in the MM5. Based on the same configuration with the tracer study, forward trajectories also indicated similar source/receptor relationships between the Metsamor and Turkey.

3. DISCUSSION

An example of the worst-case synoptic conditions for Eastern Turkey is seen in the combined sea level pressure and wind chart of March 14th, 2004 (Figure2).

Counter-clockwise circulation around the low pressure center located on Iraq, and the clockwise flow induced by the strong high pressure center on Eastern Europe, both make conditions favorable for N-NE winds over Eastern Turkey. This pattern, especially the extended dominance of ridges over cold Eastern European land mass is very common in winter months.

Tracer

After 48 h of integration in the model, a synoptic-scale circulation pattern that favors pollutant transport into Turkey is quite evident (Fig. 2). Simulated tracer transport from the Metsamor can be seen in Fig. 3. For the simulation period (00 UTC 5 July to 00 UTC 7 July), the tracer distribution at 12, 24, 36 and 48 hours are demonstrated in a, b, c, and d panels respectively.

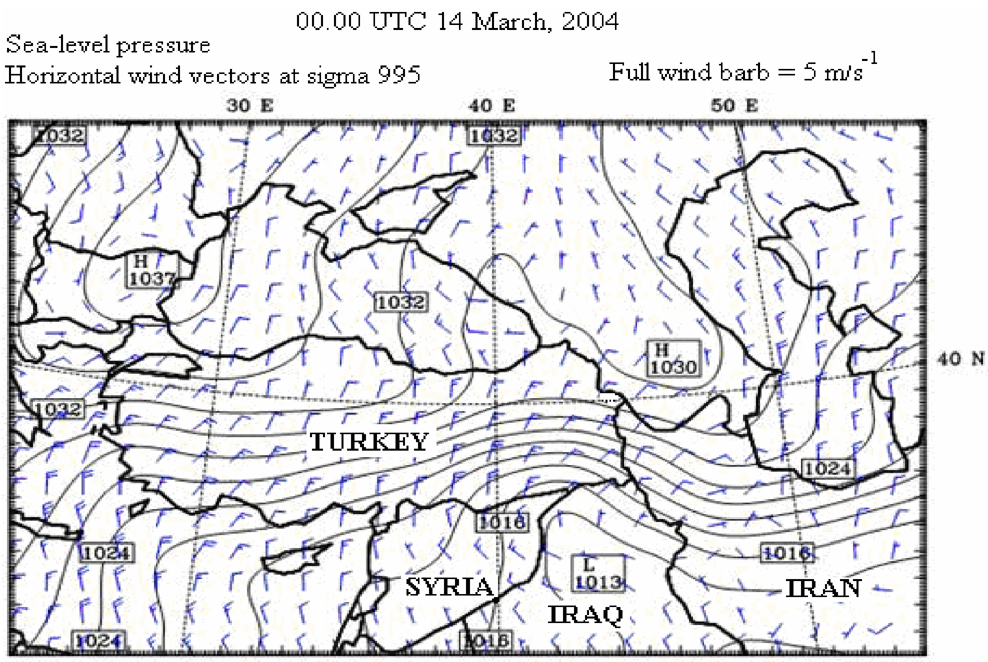
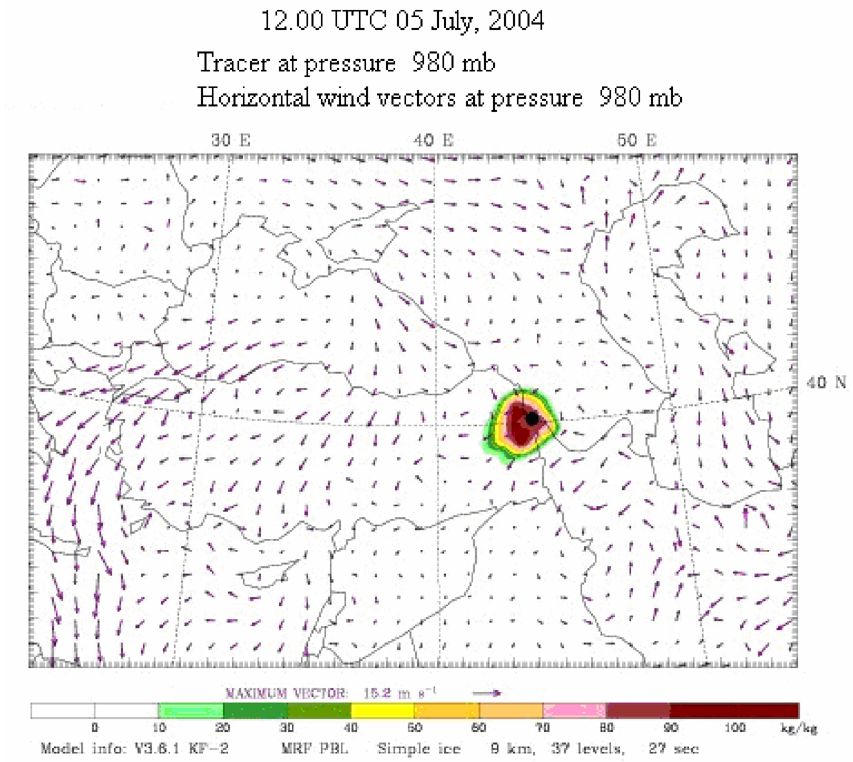


Figure 2. 24 h forecast from the model, showing sea level pressure (solid line; hPa), and wind vectors (at sigma 955) at 00 UTC14 March, 2004.

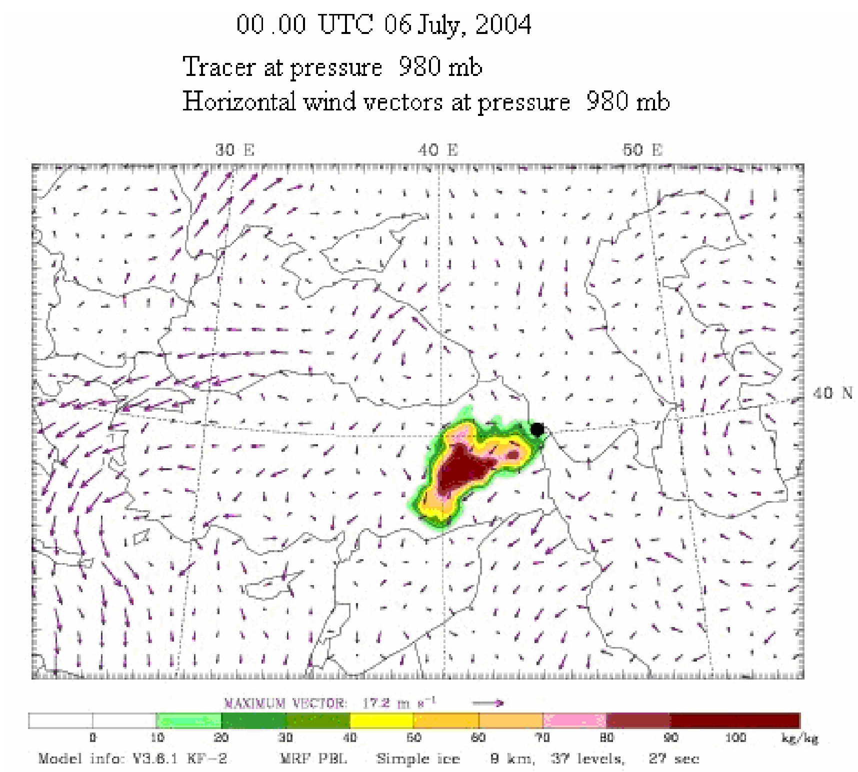
While the tracer had almost equivalent impact for each direction after 12 hours later (Fig3-a), it widened to the west which covered Eastern Turkey by the end of 24 hours (Fig3-b).

The South East of Turkey is relatively far away from the Metsamor, yet tracers reached this area after about 36 hours of transport (by 12 UTC 6 July). On the other hand, the tracer began losing its intensity when it moved to the inside of Turkey (Fig3-c). Finally, 48 hours later, the tracer lost most of its intensity and it crossed the Turkish south-eastern border (Fig3-d).

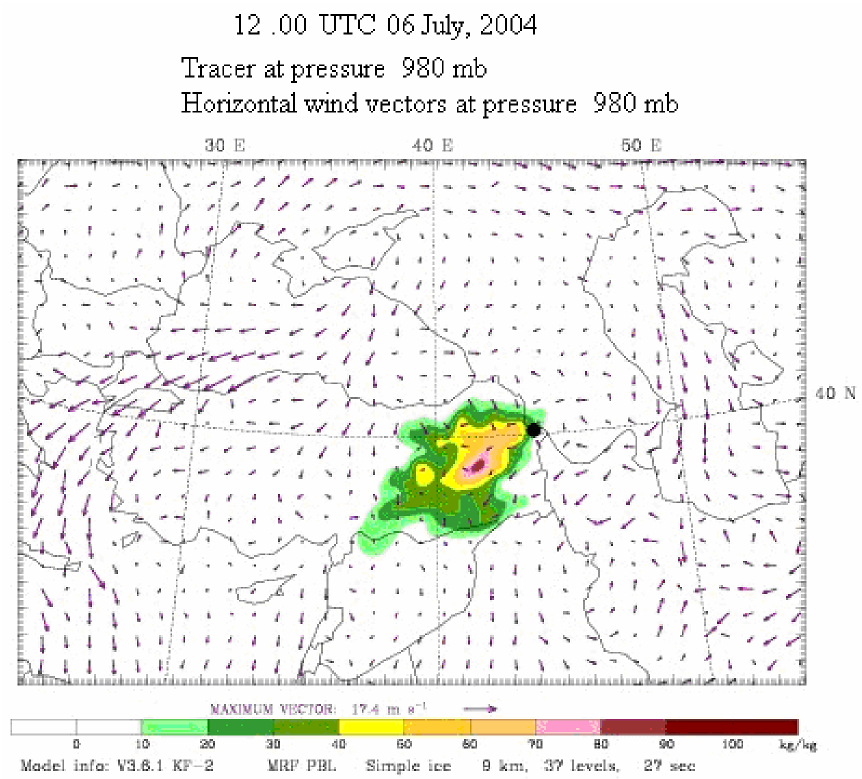
a)


12.00 UTC 05 July, 2004
Tracer at pressure 980 mb
Horizontal wind vectors at pressure 980 mb
30 E
40 E
50 E
40 N
MAXIMUM VECTOR: 15.2 m s-1
0 10 20 30 40 50 60 70 80 90 100 kg/kg
Model info: V3.6.1 KF-2 MRF PBL Simple ice 9 km, 37 levels, 27 sec

b)


00 .00 UTC 06 July, 2004
Tracer at pressure 980 mb
Horizontal wind vectors at pressure 980 mb
30 E
40 E
50 E
40 N
MAXIMUM VECTOR: 17.2 m s-1
0 10 20 30 40 50 60 70 80 90 100 kg/kg
Model info: V3.6.1 KF-2 MRF PBL Simple ice 9 km, 37 levels, 27 sec

c)



d)

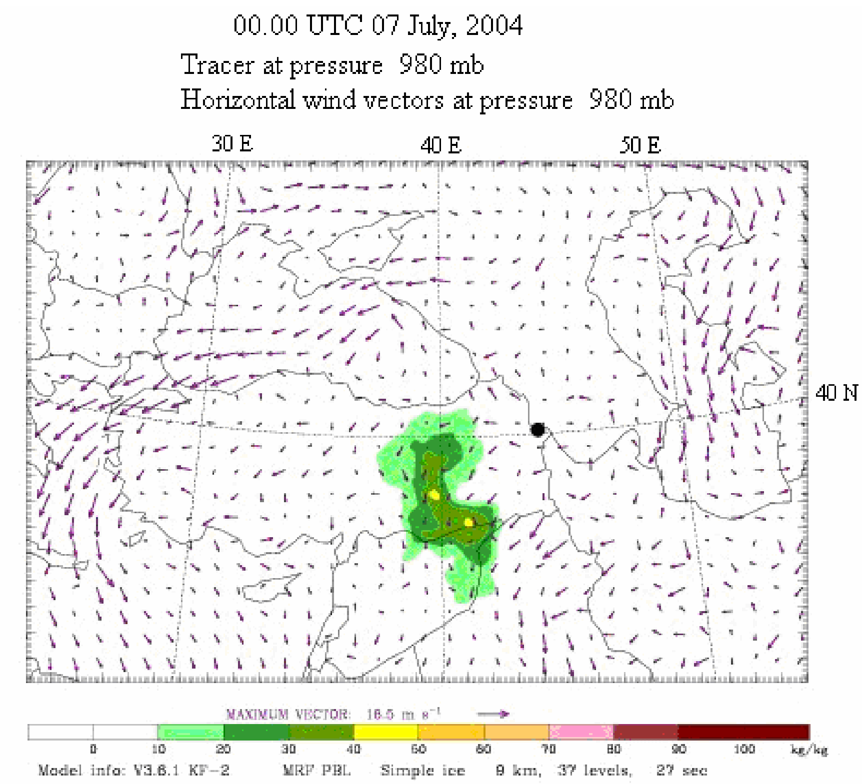


Figure 3. Simulated tracers and wind vectors at the 980 mb height at (a) 12-h simulation (b) 24-h simulation (c) 36-h simulation and (d) 48-h simulation.

Forward Trajectories

The forward trajectory method was used in the MM5 to determine the transport path of dangerous material to Turkey following a hypothetical accident in the Metsamor. Figure 4 shows 48-h forward trajectories for a summer episode. Starting at the Metsamor on 00:00 UTC July 5 from near the ground level (0.1 km) in the vicinity of the plant, forward trajectories had almost a 5-km height at the end of the simulation. These trajectories indicate the possibility of long-range transport from the Metsamor to Turkey. This result supports our hypothesis that transport from the Metsamor might play an important role in the high radioactive pollution episodes experienced in eastern Turkey during the summer episode in addition to the winter episode.

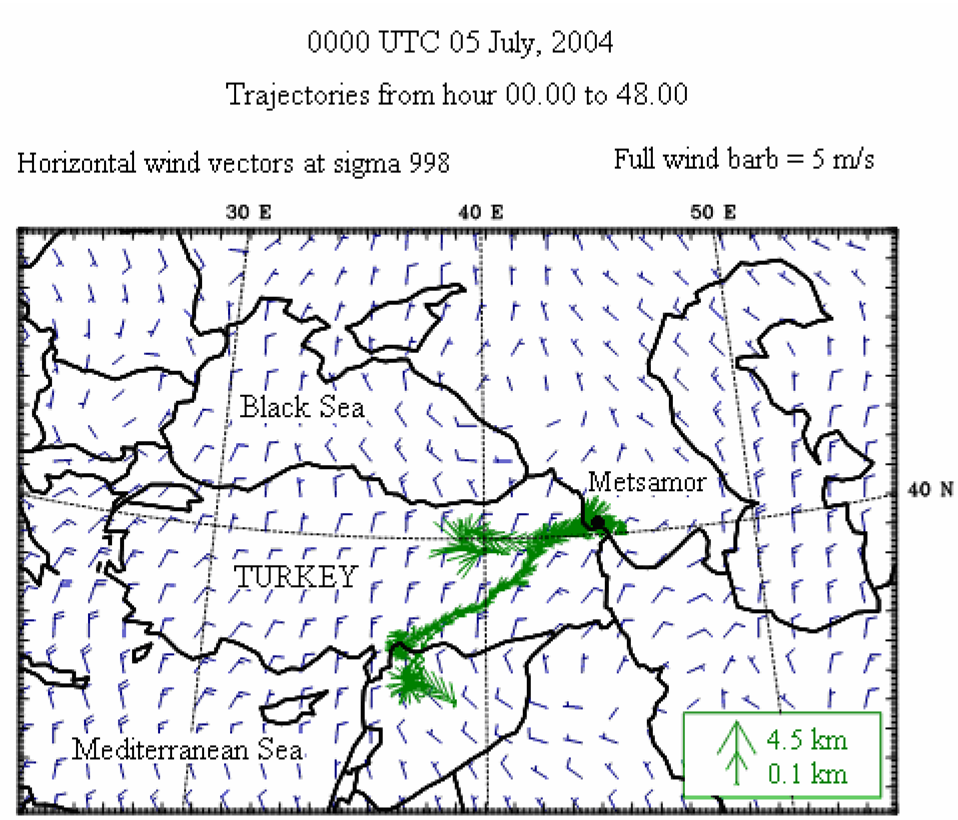


Figure 4. The model-generated forward trajectories calculated over 48-hour periods. The box which is on the bottom right hand corner of the figure indicates the initial and final heights of the trajectories.

4. CONCLUSION

Turkish authorities have not paid sufficient attention to the different aspects of safety at nuclear installations in the former Soviet Union, even though we faced a terrible experiment about nuclear accidents and their consequences connected to the Chernobyl Accident in 1986. Unsatisfactory safety at the Metsamor Nuclear Power Plant has not been the focus of attention in any official reports. As a result, an emergency response system has not been constituted up to now.

This study focuses on the threat from accidents at the Metsamor Nuclear Power Plant and the subsequent atmospheric transport of radioactive material. A tracer and trajectory analysis was chosen as a method to evaluate the problem. In the beginning, the analysis was carried out as case studies. While the tracer method was performed for the winter episode, the trajectory approach was used for the summer episode (Figure 3). The simulated tracer evolution provided qualitative proof that transport of probable radioactive emissions from the Metsamor could have an impact over Turkey with the worst-case synoptic conditions for Eastern Turkey (Figure 2). In addition, similar results have been obtained by the forward trajectory with prevailing eastern and north -eastern winds for the area (Figure 4).

Actually, the analysis of the tracer and the trajectory should be used to cover a reasonably long period of time. These studies will provide us with an impact map for the zone under study. In addition, they will enable us to see the statistical distribution of the travel time. The Metsamor project with transport simulations will give a risk map in terms of both location and time to the Turkish people from such a worst-case situation.

The above mentioned MM5T on-line model brings with itself some advantages that avoid temporal interpolation errors. The accuracy of the model is likely to enable to Turkish authorities to put forward the right precautions. All in all, it could be used as an “emergency tool” to serve Turkish alertness against nuclear accidents.

5. ACKNOWLEDGEMENTS

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