COUPLED MODELING TO ESTIMATE CINEMATIC TRAJECTORIES IN CASE OF HYPOTHETICAL LEAKING OF RADIONUCLIDES INTO THE ATMOSPHERE

Nilo José do Nascimento Franco
Laboratory of Computational Models in Engineering
Doctor Candidate in Civil Engineering, UFRJ
M. Sc. in Civil Engineering, UFRJ, 2001
Meteorologist, UFRJ, 1989
Rua Paissandu n 134 apt 502, Flamengo, Rio de Janeiro, Zip Code 22210-080
(nilo_jose@hotmail.com)

Isimar de Azevedo Santos
Department of Meteorology, UFRJ
D. Sc. in Meteorology, USP, 1998
M. Sc. in Meteorology, USP, 1986
Meteorologist, UFRJ, 1974
Presently Associate Professor at UFRJ – Department of Meteorology
(isimar@acd.ufrj.br)

Saulo Ribeiro de Freitas
Center of Weather Forecast and Climatic Studies/CPTEC/INPE
Post-Doctorate, University of São Paulo, USP, Brazil, 2000
Post-Doctorate, NASA Ames Research Center, NASA-AMES, United States, 2001
D. Sc. in Physics, University of São Paulo, USP, Brazil, 1999
M. Sc. in Physics, Pernambuco Federal University, UFPE, Recife, Brazil, 1991
(sfreitas@cptec.inpe.br)

Luiz Landau
Laboratory of Engineering Computational Models/COPPE/UFRJ
D. Sc. in Civil Engineering, UFRJ, 1983
M. Sc. in Civil Engineering, UFRJ, 1976
Civil Engineer, PUC-RJ, 1973
Presently Titular Professor at COPPE/UFRJ and head of the Laboratory of Computational Methods in Engineering - LAMCE
(landau@lamce.ufrj.br)

José Luis Drummond Alves
Laboratory of Engineering Computational Models/COPPE/UFRJ
D. Sc. in Civil Engineering, UFRJ, 1991
M. Sc. in Civil Engineering, UFRJ, 1991
Civil Engineer, UFRJ, 1981
Presently Associate Professor at COPPE/UFRJ
(jalves@lamce.ufrj.br)

Air Quality and Energy
VI-Franco-Brasil-1

Key Words: Numeric Modeling, Radinuclides Transportation, Atmospheric and Climatologic Modeling
COUPLED MODELING TO ESTIMATE CINEMATIC TRAJECTORIES IN CASE OF HYPOTHETICAL LEAKING OF RADIONUCLIDES TO THE ATMOSPHERE

Nilo José do Nascimento Franco*
Laboratory of Computational Models in Engineering;
Rua Paissandu n 134 apt 502, Flamengo, Rio de Janeiro,
Zip Code 22210-080, Brazil-55-021-22854682 - (nilo_jose@hotmail.com)

Isimar de Azevedo Santos
Department of Meteorology, UFRJ

Saulo Ribeiro de Freitas
Center of Weather Forecast and Climatic Studies/CPTEC/INPE

Luiz Landau
Laboratory of Engineering Computational Models/COPPE/UFRJ

José Luís Drummond Alves
Laboratory of Engineering Computational Models/COPPE/UFRJ

ABSTRACT

The two objectives of this study are, primarily to make some numerical simulations using two coupled models, and secondly to demonstrate the importance of the atmosphere in a hypothetical case of radionuclides leaking to the environment in special in the regional lower troposphere on Angra dos Reis Brazilian Nuclear Power Plan. To do the numeric modeling, the Nuclear Complex is considerate as a punctual source at the dominium to be studied. First of all, the methodology is validated using the volcanic particles from Etna as natural tracers of the atmospheric trajectories. Then a case study is made considering a specific synoptic situation. The data are the reanalysis from National Centers for Environmental Prediction – NCEP, the models are the Regional Atmospheric Modeling System – RAMS, and the trajectories model developed at the University of São Paulo. The more important result was to point out the importance dynamic behavior of the atmosphere as a principal factor in order to determine the possible displacement of radionuclides following meso and synoptic scales.

Key Words: Numeric Modeling, Radionuclides Transportation, Atmospheric and Climatologic Modeling

1. INTRODUCTION

The energetic crisis has been affecting industrialized countries, leading them to the development of a more efficient energetic matrix, with new alternative sources, where researchers have been trying to use environmental potential aiming at a greater energetic efficiency. Nevertheless, it’s always important to identify the possible impacts, such as those in power plants that might affect the atmosphere and the environment, bringing as a consequence problems to the population. According to data from IPCC (2001), it’s fairly evident that, due to the climatic changes that have occurred in the last years, both regional and global, the Brazilian energetic sector should be affected, mainly in face of the high level of energy consumption, requiring a better optimization of the energetic sector (ROSA, 2001).

These facts have contributed to the elaboration of several projects by Brazilian governmental agencies, such as the construction of new thermoelectric plants and, within this context, the possible installation of a nucleoelectric plant, called Angra 3, inside the Nuclear Complex of Angra dos Reis. It’s important to highlight that this region is located near two populous urban centers (Rio de Janeiro and São Paulo), and it is
also a center for tourism. Thus, knowledge of the behavior of winds, with an observational and climatological approach, is very important in case radionuclides are accidentally liberated into the atmosphere. It’s also important to know what would be the behavior of the same winds within the lower troposphere.

We have to say that the nuclear plants operating nowadays are extremely safe both operationally and structurally, but there’ll always be the possibility of a radioactive accident. According to BAKLANOV & MAHURA (2001), the past experiences always have to be remembered, like the nuclear accidents that happened in Three Mile Island in 1979 in the United States and in Chernobyl, in the former Soviet Union in 1986, with terrible consequences to the plant’s personnel, to the surrounding population and to the regional and global environment. In a short period of time, the debate on nuclear accidents became more than a simple matter of theoretical projections. In the two accidents mentioned above, the radionuclideous emissions into the atmosphere were observed both near the accident and in remote areas. The relevance of winds and atmospheric circulation in meso, synoptic and global scale is evident in the transportation of these pollutants that affected the health of thousands of people and also caused many deaths. Since the direction and the intensity of winds change frequently under the action of meteorological systems such as cold fronts, it’s necessary to observe systematically the atmosphere, so that masses of air, specially their trajectory changes, are tracked.

2. OBJECTIVES

The main aim of this paper is to simulate the atmospheric transportation of inert particles and gases exhausted from a punctual source, originated from a nuclear complex, supposing a hypothetical situation. In this research we won’t consider the radionuclideous half - time, because the main objective is to highlight the importance of the atmosphere as a primordial element in the displacement of this radioactive material (FRANCO et al, 2002). We aim at presenting a methodology capable of allowing a systematic monitoring of the atmosphere. The first goal of this research was to run a test of sensibility where we studied the displacement of the trajectories in an actual situation. In this case, though, the object of study wasn’t a nuclear plant, but the explosion happened in the Etna volcano, located in Italy, in October 28, 2002, being considered the particles originated from the volcano as a natural tracer. Afterwards, we simulated the trajectories to evaluate the displacement and the direction of the radionuclides, considering as a source the Brazilian nuclear complex, located near Angra dos Reis, in the State of Rio de Janeiro. We analyzed the period between November 29 and December 4, 2003.

3. METHODOLOGY

The principal aim of this research is to develop a methodology to evaluate the transportation of radioactive elements originated from nuclear complexes, simulating different meteorological scenarios, and to observe the behavior of the atmospheric transportation (FRANCO et al, 2003).

The data for the choice of a scenario were obtained through satellite images, taking into account the importance of the meteorological event for the region being studied. The atmospheric data are the reanalysis from the National Centers for Environmental Prediction – NCEP, related to the chosen period of time. Initially, a sensibility test was run, using a natural tracer to evaluate the suggested methodology.

Two numeric models have been used: RAMS (version 4.3) and the Trajectories Model (FREITAS, 1999). The first one is a model of mesoscale hydrodynamic (PIELKE et al, 1992), which allows simulating the displacement of the different parcels of air in the various troposphere levels, and the second one is a model of cinematic trajectories.

4. RESULTS

Here are presented the trajectories using the model by Freitas (1999) for a period where there was the liberation of volcanic particles into the atmosphere, where the simulation corresponded to a period of 24 hours of numeric integration. This modeling represents a sensibility test, which has as objective to justify the presented methodology.

Observing figure 1 (a), a picture generated through channels 4 and 5 of satellite NOAA-16, we can see the presence of the particles from the Etna. In this atmospheric condition, the formation of a volcanic plume is well characterized, a situation that can be considered a natural tracer. Due to the meteorological conditions, the volcanic plume moves over the Mediterranean and reaches the African Continent, passing between Tunisia and Libya. Since we aim to simulate the behavior of this trajectory, using the presented methodology,
looking figure 1(b), we can observe that the behavior generated through the numeric modeling is consistent with the actual situation presented in figure 1(a).

In the second phase, we tried to study a determined synoptic situation (figure 2 a). The result of the simulation is consistent with figure 2(b), where the particles move towards the south of the Atlantic Ocean. In this situation, the trajectory was under the strong influence of a frontal system. The aim of the simulation was to analyze the eventual displacements of radionuclides, in case of radioactive leaking into the atmosphere, being the nuclear complex considered a punctual source.

5. CONCLUSIONS AND RECOMMENDATIONS

This paper started with a modeling of the trajectories behavior, considering the particles originated from the volcano Etna, which in this case was considered a natural tracer. The second part corresponded to a simulation of the displacement of a trajectory, whose synoptic situation corresponds to the arrival of a cold front.

This paper has tried to demonstrate the importance of studies of the meteorological systems in the region of Angra dos Reis, associating systematic meteorological observation of the winds with numeric modeling. Because of this, it’s important that governmental sectors, when programming mitigating measures for the eventual accidents, can use detailed meteorological knowledge, as was proposed in this research, identifying the relevant atmospheric scenarios and diagnosing its respective trajectories. It’s also possible to make prognosis about the regions that might be affected and the possible impacts on the populations, in case of an accidental leaking of radionuclides into the atmosphere.

Figure 1: (a) Trajectories obtained by satellite NOAA (Source NOAA), and (b) result of the numeric simulation of the trajectories.
6. REFERENCES


Figure 2: (a) Infrared image on November 29th 2003 (Source CPTEC – INPE), and (b) numerical simulation of a trajectory.