AIR QUALITY FORECASTING SYSTEM AT FERIHEGY AIRPORT –HUNGARY

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Abstract: This paper presents an application of the EDMS dispersion modelling system to airport air quality calculations. The EDMS system is a combined emissions and dispersion model which can be used to produce an inventory of emissions generated at Budapest Ferihegy Airport, as well as to calculate pollutant concentrations on and around the airport. Daily average NO_X concentration values are predicted for 24 hours, and these forecasted values are evaluated with the concentration values measured at the air pollution monitoring stations on the area of Budapest Ferihegy Airport.

Key words: *airport air quality, dispersion modelling, EDMS modelling system.*

1. INTRODUCTION

Aviation has experienced rapid expansion as the world economy has grown, and this has produced a number of major environmental challenges. As the contribution to urban air pollution from road emissions is steadily reducing in cities of European countries, other emission sources are becoming comparatively more relevant. The contribution to air pollution levels from emissions produced by the operation of airports located close to cities is one example in this respect.

In 2005, a new project started to determine the air pollution situation at Budapest Ferihegy Airport, combining the results of measurements and model calculation. In the joint research work, the EDMS air quality modelling system was adapted and developed at the Hungarian Meteorological Service (HMS), while three measurement campaigns were performed on the area of Budapest Ferihegy Airport by the Hungarian Research Institute of Physics (*Steib et al.,* 2008). After developing the modelling system with which the air quality can be determined at the airport, a new forecasting system development has been started. This system can forecast the concentrations of several pollutants for the next day at the area of Budapest Ferihegy Airport.

2. FORECASTING SYSTEM

The newly developed forecasting system is able to produce daily average dispersion forecasts operatively for five different pollutants (NO_X, CO, SO_2, VOC, PM_{10}). The system architecture is presented in Figure 1, while Figure 2. shows the aerial map of the airport.

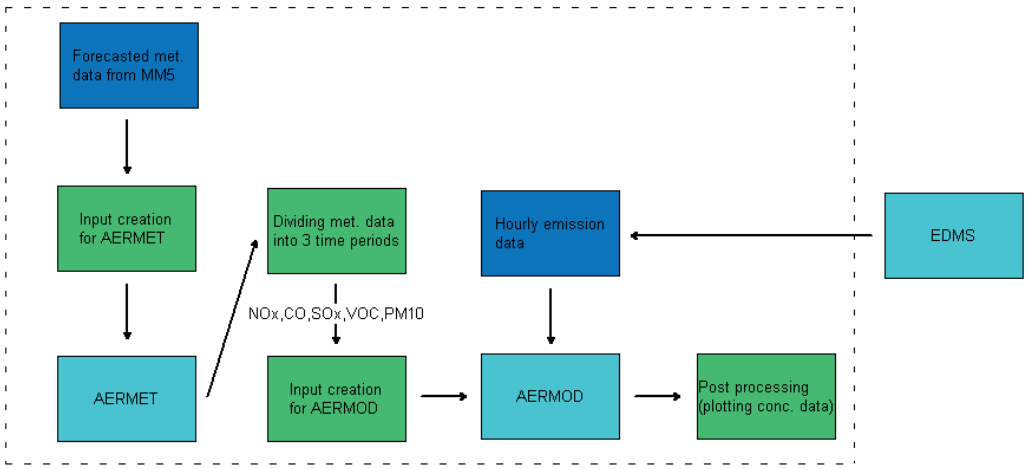

Figure. 1. Modelling system for forecasting pollutant concentrations at Budapest Ferihegy Airport.

Airport dispersion calculations are much more complex than regular dispersion calculations, because the aircraft emissions (the place of the emissions) strongly depend on the wind situation in the modelling domain (wind direction and speed). It is possible to use different configurations in the EDMS model (depending on the wind direction and wind speed). At Budapest Ferihegy Airport aircraft movements and the direction of landing and take-off are dependent on the wind gust values parallel to the runways. For this reason we work with our own program, which uses weather dependent input emission files instead of the default configurations of the EDMS. Normally, aircrafts use the 31L runway for take-off and the 31R runway for landing at Ferihegy Airport. If the 130˚ wind gust component is greater than 5 knots, direction of take-off and landing are changed. As a result of this, the direction of taxiing is also changed. In this case aircrafts mainly use the 13L runway for take-off and the 13R runway for landing.

This effect can be very important when doing dispersion calculations, since the emission of a pollutant can be significantly different during take-off and landing. Therefore, during the modelling, the place of take-off and landing should be determined as well as possible.

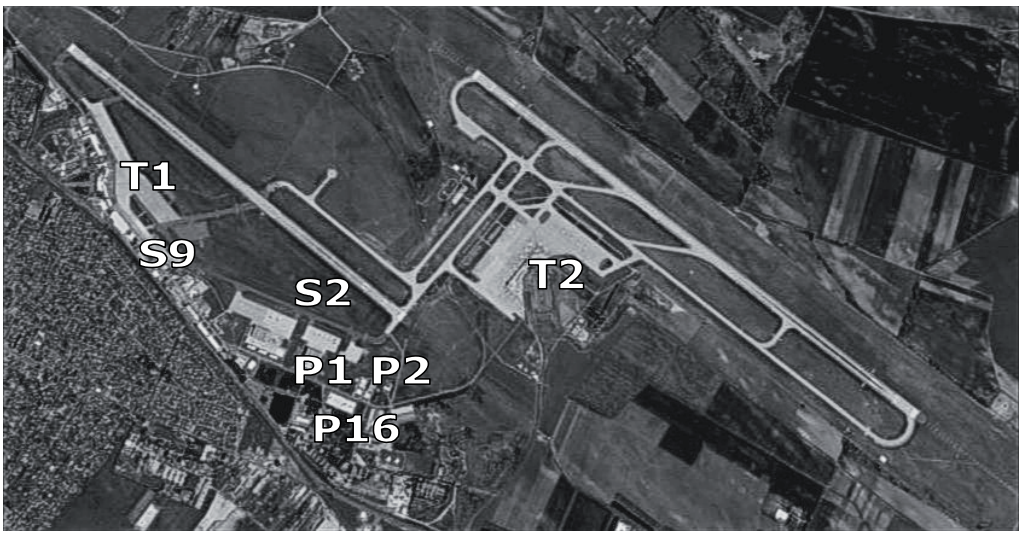

Figure 2. Aerial map of Budapest Ferihegy Airport.
P1, P2, P16: stationary sources; T1, T2: terminals; S2, S9: monitoring sites.

The constructed 24-hour long dispersion meteorological database contains hourly data. During the model run this database is divided into three parts (0-12 a.m., 12-18 p.m., 18-24 p.m.), and the wind situation is examined in these three different periods. The time periods are asymmetrical, because in the first time period (until 6 a.m.) there is very little air traffic at the airport. The hourly wind gust components are averaged for every time period. The runway-taxiway configuration of the different time periods is determined from the calculated averages. Concentration calculations are made separately in this three different time periods with the proper hourly emission data values. At the end, daily average concentrations of the five different pollutants are calculated from the concentration values of the different time periods. Depending on the meteorological situation, dispersion model runs can be executed with eight different emission inputs.

The input meteorological data are coming from the MM5 numerical weather prediction model.

3. RESULTS

Figures 3-5 represent the concentration distribution of NO_X in three different weather situations. From the five different pollutants only the NO_X concentrations are shown, because this pollutant is the most representative of the effect of aircrafts. High CO and VOC concentrations are mainly caused by the road traffic in the modelling domain, while high SO_X and PM_{10} concentrations are caused by the GSE (ground system equipments). Locations where the concentrations are estimated are known as receptors. In the modelling domain Cartesian receptor network were used with different resolutions. Near the main emission sources the resolution of the receptor network is higher (100 m), elsewhere lower (500 m). The reference point of the modelling domain is the 0-point of the airport (latitude: 47.44°, longitude: 19.26°, elevation: 146 m). The size of the modelling domain is 9x8 km. 25 (5x5) grid point values are read from the MM5 meteorological files (nearest to the 0-point). These values are averaged and passed to the meteorological pre-processor AERMET. The place of a receptor point is represented with two coordinates. The first coordinate (x-coordinate) shows the distance of the receptor point from the 0-point in east-west direction. In case of positive x-coordinate the receptor point lies east of the 0-point, in case of negative x-coordinate west of the 0-point. The second coordinate (y-coordinate) shows the distance of the receptor point from the 0-point in north-south direction. In case of positive y-coordinate the receptor point lies north of the 0-point, in case of negative y-coordinate south of the 0-point.

The calculated concentrations do not include the background concentration of the modelling domain. Only airport dependent emissions and the emissions of Road Nr. 4 (a main motorway), which runs near the airport, were took into account during concentration calculations. Figure 3 represents the forecasted daily average NO_X concentration distribution in case of north-westerly winds, while Figure 4 shows the same in case of southerly winds. Figure 5 shows the concentration distribution when the wind direction is changing during the day, so the aircrafts should change the landing and take-off directions. In the figures, black solid lines indicate the runways, black dashed lines are taxiways, black bold solid line is Road Nr. 4, and light gray polygons indicate the two terminals. The calculated concentration show, that in the area of the airport, the NO_X emissions of the aircrafts and the vehicles running in the

airport and the neighbouring motorways give near equivalent contributions to the concentration in the ambient air. In the pictures the maximum NO_X concentration places can be found near Terminal 2 and at take-off places. Other local maximum NO_X concentration values can be found near Terminal 1 and in the vicinity of Road Nr. 4. The NO_X emission of the aircraft engines is the highest during take-off phase, so it is not surprising that the mentioned local maximum place can be found at the take-off place of the runways. Because the aircraft traffic is about 25% of the whole traffic at Terminal 1, the concentration values at Terminal 1 are not as high as near Terminal 2. For the maximum concentrations near the terminals, the GSE and APU activities (auxiliary power units) are responsible. Although the total NO_X emission of the aircrafts and roadways is higher than the NO_X emission of GSE and APUs, aircrafts and vehicles emit the pollutants in much bigger area. Therefore, the effect of the GSE to the concentration values is also significant. We can say that the maximum NO_X concentration value varies between 30 and 100 gm^{-3}, depending on the daily meteorological situation. In the first case the highest concentration values caused by aircraft can be found near the 31L runway (wind blows from northwest), in the second case near 13L (wind blows from south), and in the third case near 31L and 13L (wind changes direction during the day). In the third case the concentration values at take-off place are about half of the values of the first two cases.

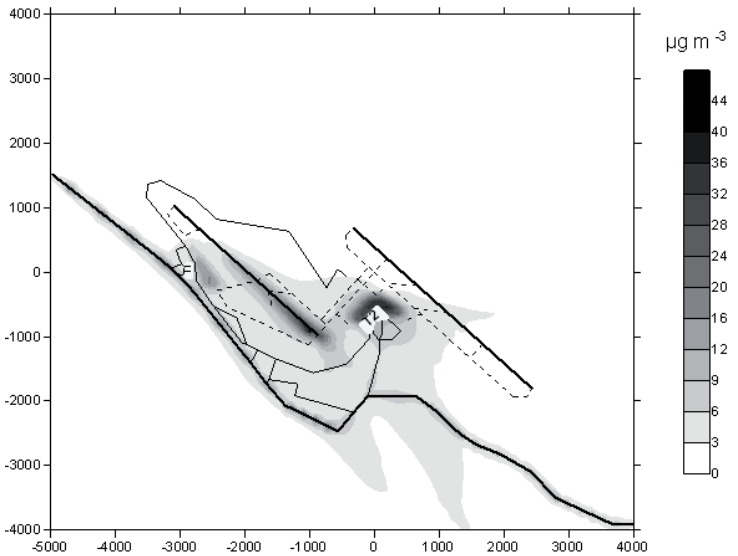

Figure 3. Forecasted daily average NO_X concentration distribution at Ferihegy Airport when the wind blows from northwest.

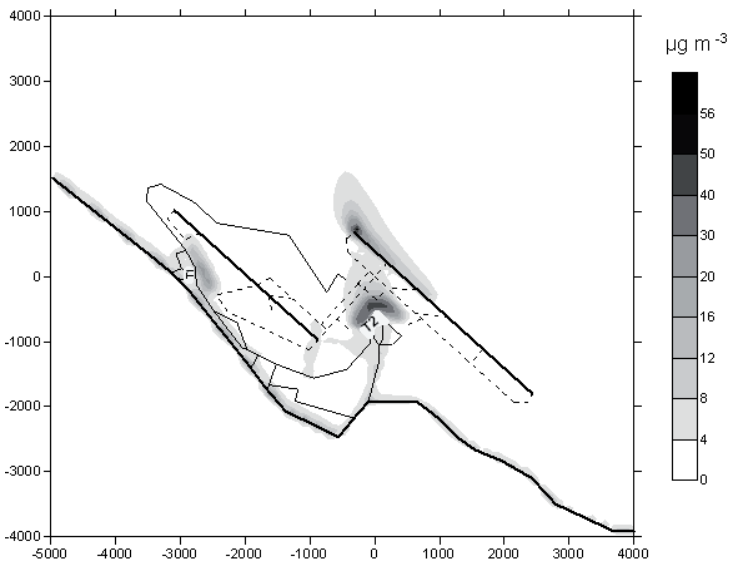

Figure 4. Forecasted daily average NO_X concentration distribution at Ferihegy Airport when the wind blows from south.

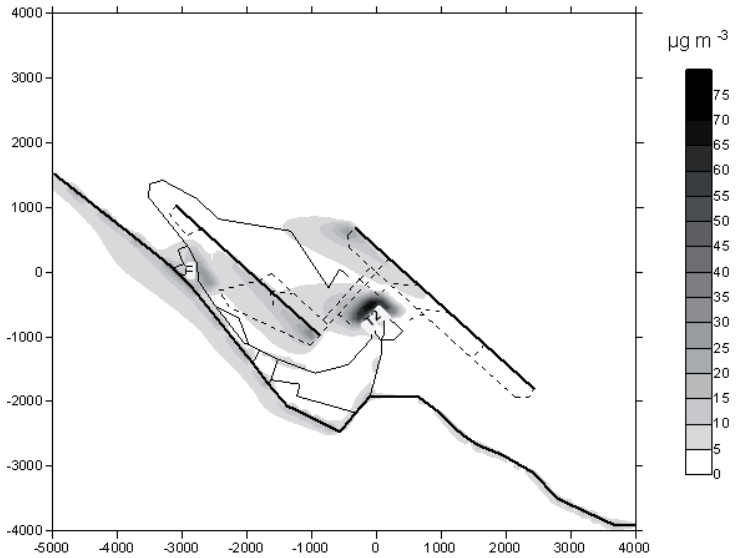

Figure 5. Forecasted daily average NO_X concentration distribution at Ferihegy Airport when the wind changes direction during the day.

As the sources at airports show large temporal and spatial variation, and so far we can use observed data measured during short time campaigns, in this first stage of model development we aimed to get a first survey of our results. For this purpose, diurnal variation of hourly averaged concentration values were compared with the modeled values in the period of May 31 – June 2, 2006. Based on the results of the measurement campaigns, air pollutant concentrations are going to be monitored continuously at the airport. Fig. 6 shows the results of the model calculations for hourly NO_X concentrations compared with the observed data, at stations 2 and 9, during the examined period. The modeled values are increased compared with the ambient NO_X concentration measured at K-puszta (48° 58' N, 19° 33' E) background monitoring station. The course and order of the modeled and observed data series are very similar, and in most cases, the peaks can be found at the same time at both measuring sites. This result shows good promise for that we will be able to determine the time and value of the highest peaks of NO_X concentration at both sites.

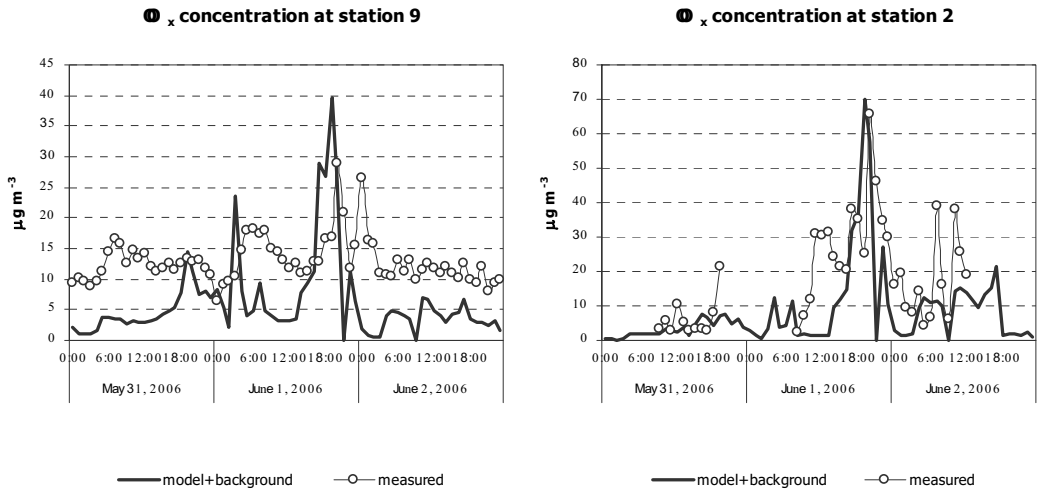

Figure 6. Comparison of the modeled and measured hourly averages of NO_X concentration at station 2 and 9, during May 31–June 2, 2006.

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