ROMAIR: IMPLEMENTATION OF AN AIR QUALITY MODELING AND FORECASTING SYSTEM IN ROMANIA

Eva Eriksson¹, Fanny Lasry¹, Jacques Moussaﬁr¹, Richard Ngo¹, Patricia Lungu², Corina Lupu², Bogdan Gird², Alessandro Nanni³, Cristina Pozzi³

¹ ARIA Technologies, 8 rue de la Ferme 92100 Boulogne-Billancourt, France
² NEPA, Splaiul Independentei nr.294, Bucharest, Romania
³ ARIANET Srl, Via Gilino 9, 20128 Milano, Italy

Abstract: The EU directives on air quality were integrated into the Romanian legislation as a consequence of Romania joining the European Union in year 2007. The ROMAIR LIFE+ project aims at helping the Romanian authorities to tackle increasing atmospheric pollution, with a comprehensive air quality modeling and forecasting system. The system has been implemented at the National Environment Protection Agency (NEPA) in Bucharest during the years 2010 to 2012 and provides the authorities with an operational air quality forecasting model as well as a decision support system enabling strategic planning for the study of future emission reduction scenarios. The approach chosen by ROMAIR is fully in line with the European Union's perspective and priorities, including the:

• Realization of a complete emission inventory for Romania, inserted in a Geographical information System, and processed for the air quality model
• Implementation and configuration of a meteorological model (WRF) and an air quality model (CHIMERE) for both primary and secondary pollutants set up for 3 different domains: European, National (Romania) and Regional scale (Bucharest region). The system is operated on a daily basis, and in forecast mode, with Web display of results made available to the public on internet
• Identification of critical areas and critical pollutants with a due consideration to secondary pollutants like O3 and Particulate Matter
• Comparison of model output with observations at air quality stations belonging to the Romanian air quality network.
• Organization of Lidar field experiments for the meteorological model validation

The validated modeling system has been used in scenario mode for evaluating national and regional plans related to emission abatement strategies aiming to reduce air pollution.

Key words: atmospheric pollutant emissions, air quality modeling and forecasting, decision support system, air quality directives, air pollution management, traffic assignment model, model validation

INTRODUCTION

The system implemented provides the authorities with complementary tools for air quality management enabling operational air quality forecasting as well as strategic planning for the study of future emission reduction scenarios. The project was carried out during 30 months, from January 2010 to June 2012, and consisted of three major phases:

• A first phase of data collection of emissions and other data necessary for modeling of pollutant dispersion took place during the first year. Industrial and diffuse emissions were processed, as well as emissions resulting from traffic. A geographical information system (GIS) was put into practice and was intensively used throughout this step.
• A second phase of implementation and validation of the meteorological and dispersion forecast models was carried out during the second year. Field experiments with monitoring tools (mobile monitoring station, Lidar equipment) allowed fine tuning and calibration of the air quality forecast system.
• A third phase of scenario development was finally organized during the last year of the ROMAIR project. The scenario study has enabled the elaboration of strategic planning of air quality for Romania.

METHODOLOGY

An exhaustive inventory of emission sources in Romania was carried out by collecting available data for the most recent year. The data collected for ROMAIR is largely based on a bottom up approach and includes state-of-the art emission inventory estimations and calculations for Romania. The data collection was organised by NEPA and involved a large number of data providers. The methodology used for the emission inventory is based on the CORINAIR standard procedures defined by the European Environmental Agency. The final ROMAIR emission database contains:
• Over 4 000 large point sources (industrial stacks etc...)
• 16 420 line sources (on-road traffic, maritime routes, air traffic corridors,...)
• About 8 000 area sources (diffuse emissions such as residential heating, agricultural activities, evaporation losses from extraction and distribution of fossil fuels,...)

Traffic emission modelling
The calculation of traffic flow and traffic emissions in Romania with special focus on Bucharest was further carried out within the framework of the project. For this purpose, all relevant information on the road traffic structure in Romania has been collected (road infrastructure, vehicle flow, composition of the vehicle fleet).

The set of traffic counting data collected was provided by the Romanian Auto Register (RAR) and the Ministry of Transport. The models CarUSO (traffic assignment model) and TREFIC (emission calculation model) were configured and applied for the ROMAIR traffic simulations.

All the data from the emissions inventory was aggregated and processed with the modular package EMISSION MANAGER, which processes and prepares model-ready inputs for the chemical transport model CHIMERE.

- a special consideration was given to the VOC emissions, which require further segregation into individual species. Using the basic IER profiles, VOC emissions were split over 334 VOC species
- source geometry (polygons, lines, points) were projected to the regular modelling grid cells
- total emissions accounted for in the emission inventory were modulated in time

Figure 1. a) Emissions calculated on the National and Bucharest road network - 2008 data - NO\textsubscript{X} (kg/km/h). b) Diagram of relative errors versus measured traffic flows (higher scattering for low traffic flows, smaller errors for high traffic flows)

Figure 2. Preparation of model-ready emission input from inventory data

Merge of Global and Local Emission Inventory
In order to avoid simulating a domain with “clean-air” inflow over the territory of Romania, the emissions from neighboring countries has been accounted for. The emission data was taken from the EMEP database (European...
Monitoring and Evaluation Program) and includes a large part of Europe, Turkey, Ukraine and the south western part of the Russian Federation. The figure below illustrates the emissions of NO2 obtained on the three ROMAIR modelling domains after integration of the global (EMEP) inventory and the local ROMAIR inventory carried out by NEPA.

Figure 3. Emissions of NO2 obtained on the three ROMAIR modelling domains

GIS data base
The various data necessary for air quality modelling has been geolocalized and incorporated into a GIS database. The ROMAIR ArcGIS database includes the geographic boundaries for all administrative entities (regions, judetes, and municipalities), emissions sources (LPS, traffic links, area sources, airports,...), land-use characteristics, air quality and meteorological stations etc. The database has further been completed with information on emissions sources (LPS, traffic links, area sources, airports,...) as well as statistics on population and fuel consumption for the different administrative entities.

Meteorological and Dispersion Models
The sequence of forecast and simulation models used in the ROMAIR system for meteorology (WRF) and air quality (CHIMERE) is widely used by Public Bodies in France and in Europe. The Weather Research and Forecasting (WRF) model is a numerical weather prediction (NWP) and atmospheric simulation system designed for both research and operational applications. The CHIMERE multi-scale model is primarily designed to produce daily forecasts of ozone, aerosols and other pollutants and make long-term simulations for emission control scenarios. It has been developed by the association of three main French laboratories (IPSL, INERIS and LISA).

The ROMAIR air quality forecasting system implemented at NEPA has been adapted and tuned to Romanian conditions. The operational system is currently issuing daily reports to inform on the dispersion of criteria pollutants and maps of pollution levels are available to the public on the ROMAIR web site.

Validation of the models and LIDAR field campaign
For the validation of the photochemical dispersion model, CHIMERE, daily predictions where compared with observations at a selection of ambient air quality stations. Hourly time series of air quality data were extracted from the model predictions and compared to experimental data, focusing on high pollution episodes for O3, NO2 and PM10. The comparison of model output with measurements was made with data from 45 air quality stations selected from the National Air Quality Monitoring Network (RNMCA) and 23 meteorological stations belonging to the National Meteorological Administration in Romania (NMA). Statistics have been computed for each station. For ozone, 16 stations over the 28 stations measuring O3 showed good results for bias (< 5 ppb) and 21 stations show good results for RMSE (<12 ppb). For NO2, 17 stations over the 36 stations measuring NO2 show a good result for the bias (<50 ppb) and 31 stations show good results for RMSE (<65%).

To increase the accuracy of the models and to provide access to innovative modelling technologies, a twin LIDAR (acronym for LIght Detection And Ranging) was used for obtaining vertical wind velocity profiles (wind LIDAR) and mixing height (aerosol LIDAR) over Bucharest.
The results generally showed a good correlation between model and measurements thus confirming the quality of the forecast of winds generated by the meteorological model implemented in the ROMAIR system. It could be noticed that the model tended to slightly overestimate the wind speed compared to the lidar measurements for the layers close to ground (the mean relative bias calculated decreases with height). This is a tendency which has already been observed during similar studies carried out with the WRF meteorological prediction model. The analyses further showed that the model slightly overestimated the PBL during convective periods, and underestimated it during winter periods. In the latter case, it should however be noted that the data provided by the Lidar were close to the device detection limit.

SYSTEM APPLICATION (SIMULATION OF EMISSION REDUCTION SCENARIOS)

The validated modelling system was finally applied in scenario mode for evaluating national and regional plans related to emission abatement strategies aiming to reduce air pollution. Five scenarios were elaborated and defined jointly by NEPA and ARIA in collaboration with local authorities and project stakeholders who had a consulting role for elaborating and approving strategies on emission reduction:

- a “business as usual” scenario for which future projections were made without any supplementary regulations on emissions.
- two traffic scenarios for which the impact of the introduction of bus lanes and a restriction on the circulation of Heavy Duty Vehicles in the city center of Bucharest was tested
- two industrial scenarios for which 2 hypothesis were tested:
  - Greenhouse gas scenario and related emission reductions
  - The National Emission Reduction Plan for sulfur dioxide (SO2), nitrogen oxides (NOx) and dust from large combustion plants

The scenarios chosen should be considered as indicators of realistic short or medium term solutions to air quality problems and traffic planning. The modelling results show a global decrease of pollutant concentrations between year 2009 and year 2015, despite the increase of emissions in the industrial sector and the increase of the number of vehicles (decrease of 1-5 ppb for NO2 and CO over Romania and about 60 ppb for CO in Bucharest). The reason mainly resides in the renewal of the traffic fleet which will consist of vehicles with improved pollution...
abatement technology in year 2015. The industrial scenarios showed a more general impact on the national level whereas the impact from the traffic scenarios was localized to the city center of Bucharest (10 ppb for NO2 and 130 for CO at peak hour). The simulation of the strong measures suggested by the National Emission Reduction Plan for large combustion plants indeed lead to the most important reduction of pollutant concentrations for SO2 (95 ppb), PM (40 µg/m3) and NO2 (60 ppb).

CONCLUSION AND FUTURE USE
The existing ROMAIR tool is a state-of-the-art system for air quality forecasting on national and regional level, installed at the National Environment Protection Agency (NEPA) and allowing to communicate on air pollution levels forecasted over Romania. One of ROMAIR's objectives was to have a significant impact on the awareness of atmospheric pollution by a large audience. Therefore, a wide panel of communication and dissemination tools has been implemented, such as a web portal (www.romair.eu) with direct information on pollution and air quality matters as well as best practices.

![Figure 6. ROMAIR web site allowing the public to consult the daily forecast of air pollution in Romania](image)

The ROMAIR system will further serve as an instrument for supporting the implementation of EU policy and legislation in the field of air quality. It will be particularly helpful for assessing pollution control in the country with the aim to reach the main objectives of the National Strategy for Atmospheric Protection and the EU air quality directives.

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