Overview of JCAP II Air Quality Model Integration System (Japanese version of Models-3)

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1. Introduction

No integrated systems for air quality simulation including vehicle emissions calculation were established in Japan. Under a joint research program between auto and oil industries organized by Japan Petroleum Energy Center called “Japan Clean Air Program (JCAP)”, we developed traffic flow model, emission inventory model and air quality simulation model, which enables a detailed analysis of the impact of vehicle emissions, and provided data that could contribute to environmental policy making to policy makers.

And under JCAP II (second phase of the joint research program), we developed “JCAP II Air Quality Model Integration System”, so-called a Japanese versions MODELS-3. The air quality models developed under JCAP are integrated, so that the integration system enables a consequent simulation that ranges from emissions estimation to air quality simulation, and disclosure of the system has been done in June 2007.

Purpose of the disclosure is to promote the use of the system by people involved in air quality research in industry, government and academia, and to become a common tool that might be useful for discussion for air quality improvement in Japan.

2. JCAPII Air Quality Model Outline

JCAP II Model is divided into two parts: urban and roadside air quality simulation models, each of which consists of traffic flow model, emission inventory model and air quality model. (Fig.1)

Target area of Urban air quality model ranges from several thousands to several hundreds km including whole Japan to Kanto area, that of Roadside air quality model ranges from 1 to 5 km square surrounding an intersection on a highway.

	Urban area	Roadside
Traffic flow	・**Macro-scale** Allocation calculation method	・**Micro-scale** Measured per vehicle, Chasing method
Emission Inventory	・**Motor vehicles** ・**Non-auto sources**	・**Motor vehicles**
Air Quality Model	・**Meteorology** ・**Air Quality prediction** Advection/diffusion, Photochemical reaction	・**Airflow/ diffusion calculation** Computational fluid Dynamics (CFD)

Fig.1 JCAP II Air Quality Model Configuration

JCAP II Air Quality Model Integration System consists of five submodels and a sever system, as shown in Fig.2: 1) Urban motor vehicle emission inventory model, 2) Urban non-auto source emission inventory model, 3) Urban Air Quality Model (airflow + air quality), 4) Roadside motor vehicle emission inventory model and 5)Roadside Air Quality Model.(Fig.2)

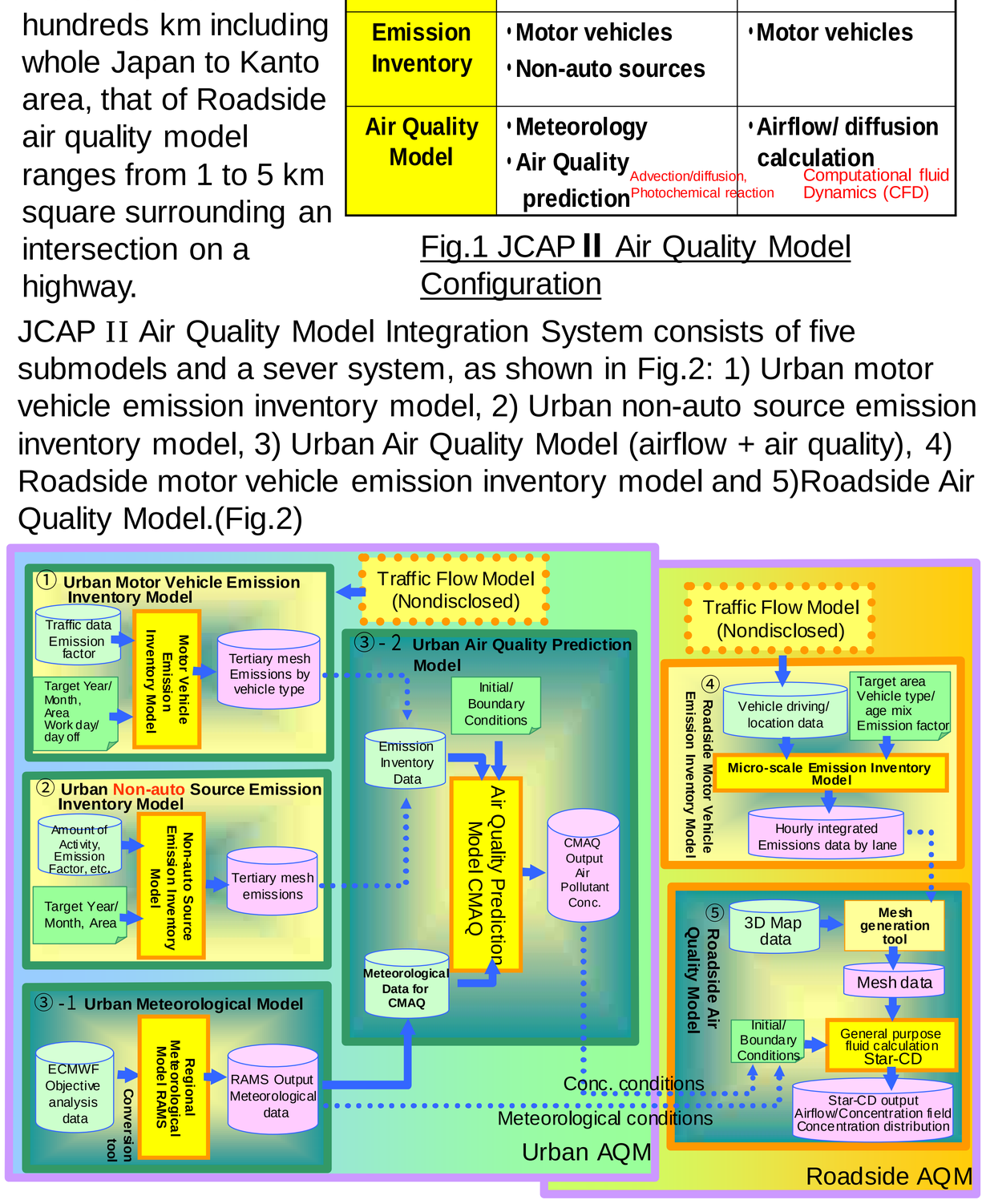


Fig.2 JCAPII AQM Integration System Association Chart

3. JCAPII Air Quality Model Integration System Features

3.1.Urban Motor Vehicle Emission Inventory Model

Urban motor vehicle emission inventory model is a simulation system. Use traffic volume and vehicle speed from Road Traffic Census data, vehicle population and other data that are allocated to grids as input data, and calculate emissions of each species by vehicle type and emission process as grid data.

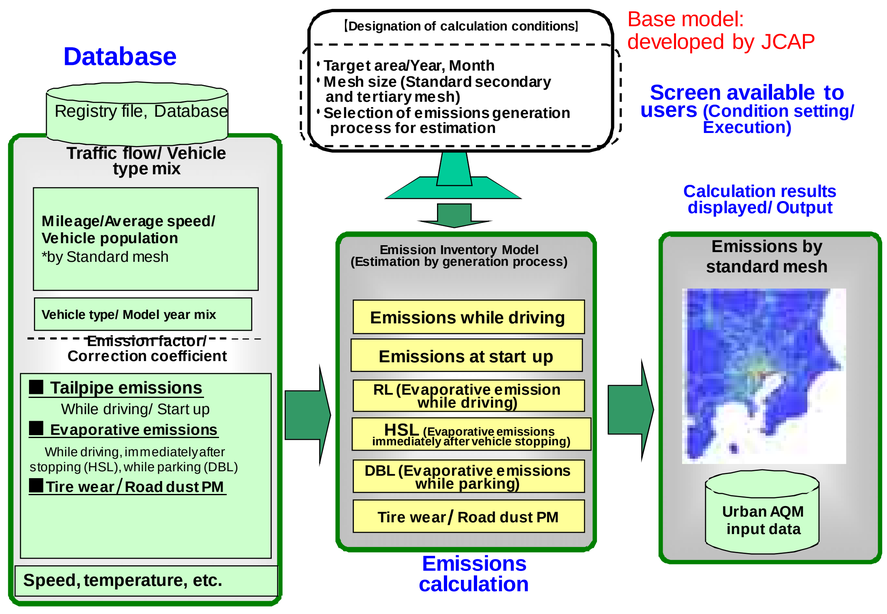


Fig.3 Motor Vehicle Emission Inventory Model Schematic Diagram

In this model, consideration is taken of not only tailpipe emissions but PM including tire wear and road dust, evaporation loss, and emissions during parking (Fig.3).

Traffic volume grid data by vehicle type and time are developed from traffic flow data on major roads in FY 1999 Road Traffic Census data (cross-sectional traffic volume and average vehicle speed during congestion by link (a road divided by several km for survey) (at a point/day)). Grid data are generated by apportioning link length (L), cross-sectional traffic volume by vehicle type (Si), and average speed during congestion (V) within a grid cell by time period. Emissions from vehicles traveling within a grid cell are calculated by vehicle type, species and time period, using correction coefficients including mileage (calculated from Si x L), emission factor, vehicle speed and etc. (Fig.4) . Roads other than major roads are defined as minor streets, average traffic volume on minor streets within the grid is calculated separately to calculate emissions on major roads.

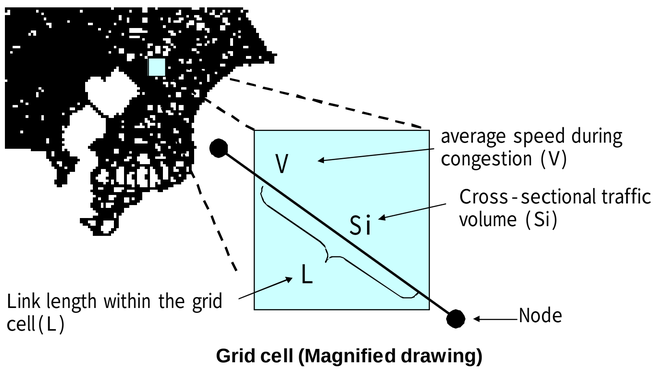
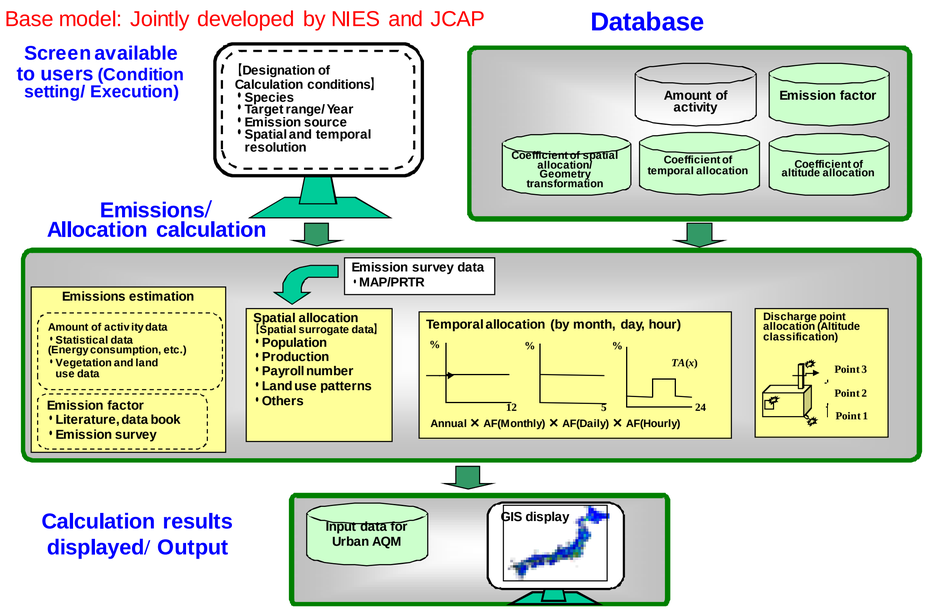


Fig.4 Traffic flow grid cell data

3.2. Urban Non-Auto Source Emission Inventory Model

This is a system that performs spatial allocation of emissions from non-auto sources(Fig.5). First of all, multiply the amount of activity data (including fuel consumption and etc.) by emission factor to calculate total emissions in Japan, and using appropriate substitute apportionment data including factory shipment value, etc., perform

spatial allocation of the total emissions, such as prefectural allocation, grid cell allocation or other allocation (Fig.6).



This system can also perform monthly and hourly allocation, or allocation considering emission height.

Fig.5 Urban Non-Auto Source Emission Inventory Model Outline

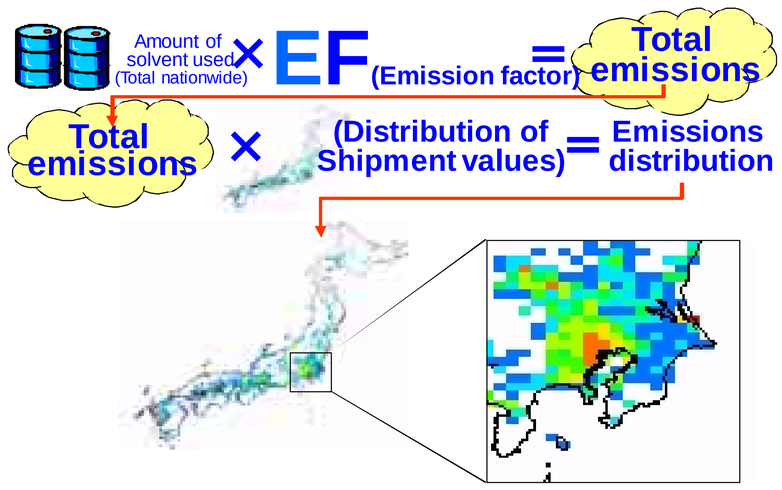


Fig.6 Urban Non-auto Source Emission Inventory Estimation Method

3.3 Urban Air Quality Simulation Model

This system consists of two sections: A section covers meteorological simulation using ECMWF data as input data, and another section covers calculation of pollutant concentrations in the air using meteorological and emission inventory data as input data. RAMS4.4 is used as base model for meteorological simulation, and CMAQ4.4 for air quality simulation (Fig.7).
In both systems integrated interface is provided in each system, which manages up to triple nesting (Fig.8).

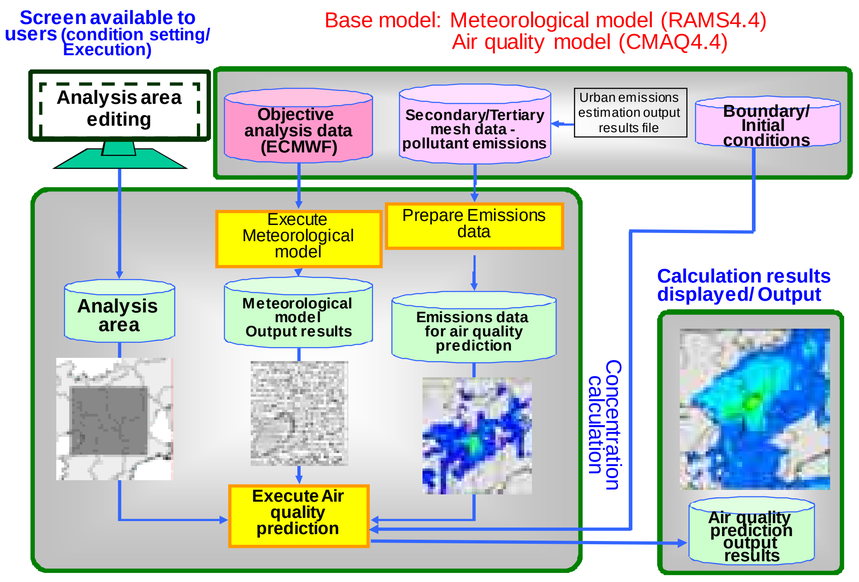


Fig.7 Urban Air Quality Simulation Model Outline

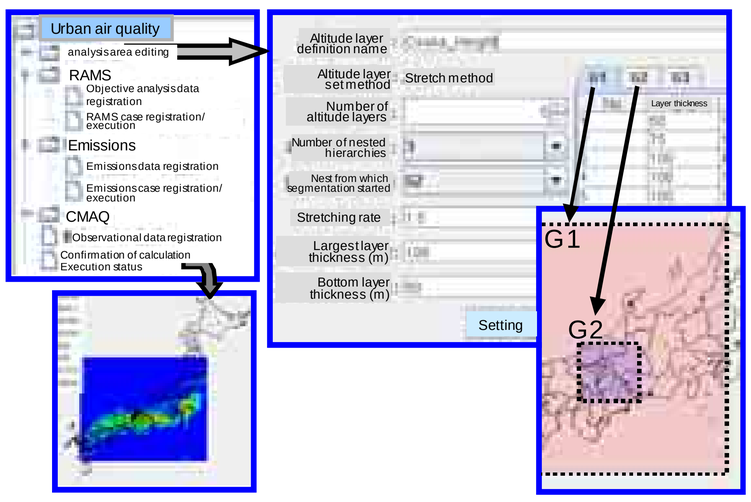
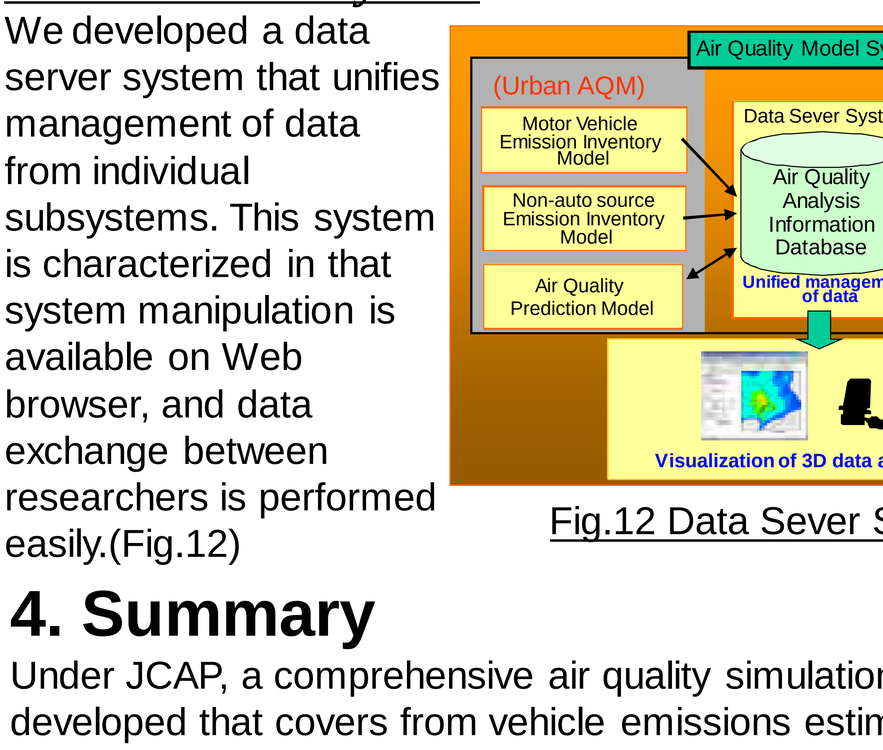


Fig.8 Graphical User Interface for Urban Air Quality Simulation Model

3.4. Roadside Motor Vehicle Emission Inventory Model

This system calculates emissions from individual vehicles corresponding to vehicle speed and acceleration, using output results from Micro-scale traffic flow model as input data that enable to express actual vehicle behavior (including starting, stopping, accelerating and etc.), and based on emission maps under transient conditions developed under JCAP(Fig.9). This system can calculate target species including NOx and etc. with resolution of 1m, and their hourly integrated values. Therefore, target area ranges from 1 to 5 km square at the largest, so that this model is applicable to estimation of emissions surrounding an intersection on a highway with frequent starting/stopping in traffic. Prior to estimation of transient emissions, chassis dynamometer testing should be conducted to measure transient emissions in JMEC mode test cycle, and emission map of vehicle speed and driving force should be prepared using the data. Transient emission map was prepared using data from about 100 vehicles under JCAP. And vehicle speed and acceleration data from traffic flow model are converted into driving force taking into consideration load, road grade and so on, so that transient emissions are calculated with the emission map (Fig.10).



JMEC: A test cycle based on MEC 01-03 cycle of Comprehensive modal emission model (CMEM) and modified to suit with vehicle driving conditions in Japan

Fig.10 Transient emissions estimation method

3.5 Roadside Air Quality Simulation Model

Star-CD by CD Adapco Co., is used as base software in this model. First, incorporate building shape information into the model using 3D digital map, generate spatial grid cells, and do air flow field calculation. Motor vehicle emissions in the target area, which are calculated using Roadside Motor Vehicle Emission Inventory Model, are inputted into the model, and advection/ diffusion calculation is done to calculate concentrations of vehicle-derived pollutants. (Fig.11)

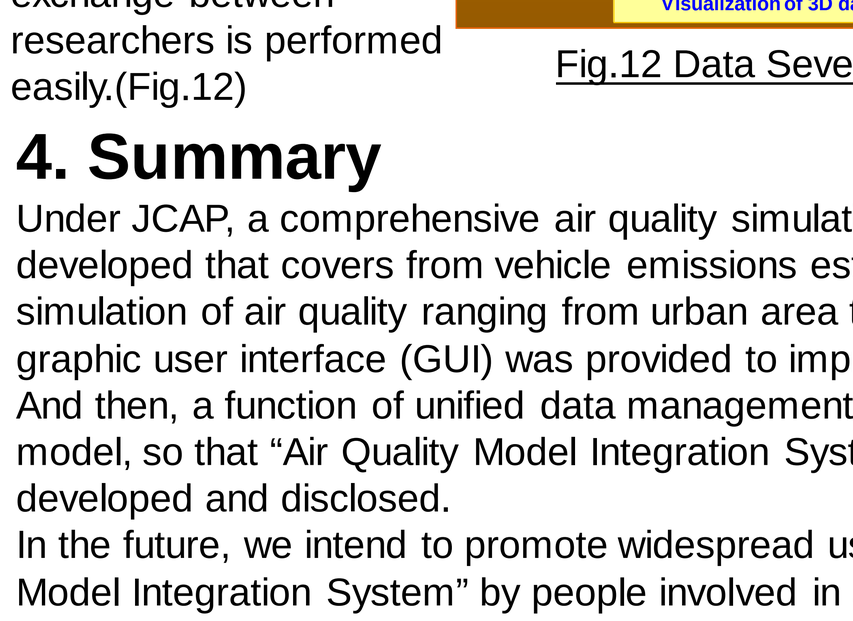


Fig.11 Roadside Air Quality Simulation Model Outline

3.6 Data Sever System

We developed a data server system that unifies management of data from individual subsystems. This system is characterized in that system manipulation is available on Web browser, and data exchange between researchers is performed easily.(Fig.12)

Fig.12 Data Sever System Outline

4. Summary

Under JCAP, a comprehensive air quality simulation model was developed that covers from vehicle emissions estimation to multi-scale simulation of air quality ranging from urban area to roadside, and graphic user interface (GUI) was provided to improve in operability. And then, a function of unified data management was added to the model, so that “Air Quality Model Integration System” has been developed and disclosed.
In the future, we intend to promote widespread use of the Air Quality Model Integration System” by people involved in air quality research in academia, industry and government in Japan, and expect the system to become a tool served as common basis of discussion for air quality improvement in Japan.