RF-073 Development of Multivariate Analysis and a Neural Network Approach for Suspended Particulate Matter (SPM) and Air Pollutants （Abstract of the Final Report）

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[Abstract]

It is very important subject to concern the air pollution, especially for Suspended Particulate Matter (SPM) for the sustainable modern life. The air pollution involving SPM is a serious problem for human health care in the eastern Asian mega cities. Nagareyama city of Chiba prefecture is also lying in a very similar situation to such eastern Asian mega cities.

The SPM density and meteorological measurements have been performed to comprehend the eastern Asian air pollution mechanisms utilizing multivariable and neural-network analysis to extract the environmental index marker showing the level of the air pollution.

We would like to propose the visualized aerosol distributions in the atmosphere by commercial available digital cameras. The mod-pictures enable to show the SPM distribution in the air surrounding the local area, where is the place for taken pictures. And also the RGB brightness demonstrates the SPM characters.

1. Introduction

Air pollution in the eastern Asian mega cities is very serious problem for the human health care. We have analyzed suspended particulate matter (SPM) and nitrogen oxide (NOx) to demonstrate the pollution level at different places by using principal component analysis (PCA) and cluster analysis (CA).

SPM is classified as an aerosol. The major SPM sources are sub-categorized to the SPM accompanied with the human activities and natural SPM. The former SPMs are exhaust from the internal combustion engines, reactions between hydrocarbons and ozone. The later SPM is from volcanic ashes, the salt-particle of the sea, and yellow sand. NOx is a potential substance of the photochemical oxidant and acid rain.

The detection of SPM is difficult for the usual citizens, because the equipments of SPM detection are very expensive and not easy to handle for non-trained people. The detection of SPM is expected to be easier by the developments and utilizing the visualization instruments of light scattering of SPM. The averaged particle diameters of SPM are 1 ~ 10 μ m, which scatters light by “Mie-scattering” mechanism. The detection of Mie-Scattering from the total light scattering involving Rayleigh-scattering is a very important issue for the visualization of SPM. The Mie- and Rayleigh scattering intensity depends on the wavelength of the light, λ^{2} and λ^{-4}, respectively. The stronger Mie-scattering is observed along the light direction. Amount of the SPM is in order [ppb]; therefore, we detected the Mie-scattering under the strong light, the sun by commercial available digital cameras.

In this project, we have planned to develop a new method to illustrate the SPM distribution observed by the limited number of data points, which is frequently appeared in the important subjects of environmental sciences. It is usually difficult to draw the SPM distribution map by the requirements of triangular or square lattice data acquisition. The calculated additional points for the enough amounts of materials are estimated by the program Compensation Quantitative Structure-Activity Relationships (CQSAR[1), 2)]) based on perceptron type neural network.

2. Research Objective

The multivariable analysis methods and neural network analysis, evaluation and integration of environmental parameters are applied onto the observed SPM and meteorological data collected in the human living environments, and the pictures taken by a commercially available digital cameras has been demonstrated as the easy detection method of SPM.

3. Methods and Materials

The principal component analysis (PCA) and cluster analysis (CA) are demonstrated to be efficient index for indicating the air pollution level of SPM and NOx at different places measured Metropolis of Tokyo, Chiba , Saitama prefectures, and Kawasaki city, Japan in 2005. The data for total 314 observation points were collected.

The digital image data are deconvoluted to R(620 nm), G(530 nm)and B(430 nm) fractions. The collected images were stored as the RAW-format image data. The image data representing the SPM distributions were extracted from the RAW images by newly developed image analysis software. And we processed R-image part of the pictures as mod-picture.

The program, CQSAR was used to present a method for drawing a SPM distribution map. The first step of CQSAR is to interpolate defective parts of descriptors. The selection depends on the number of data and characters of the data set. Three different types of interpolation methods, variable absolute-function fitting, parametric observed-vector method, 3-layer neural network method, and an arithmetic progression, were applied. The first two methods were for small data sets. The second step of CQSAR is to calculate the multi regression analysis based on the non-linear fitting functions of neural networks. The propagations of error caused by interpolations in the first step were evaluated without the error increment. The 31 observed data taken at Seoul, Korea on April 13-14, 2008 were applied. Additional points were generated by CQSAR, and the CQSAR generated data were used for drawing a distribution map

4. Result and Discussion

The year-round averaged data for NOx were scattered in contrast to the data for SPM. The correlation between SPM and NOx was estimated to be very weak (Figure 1).

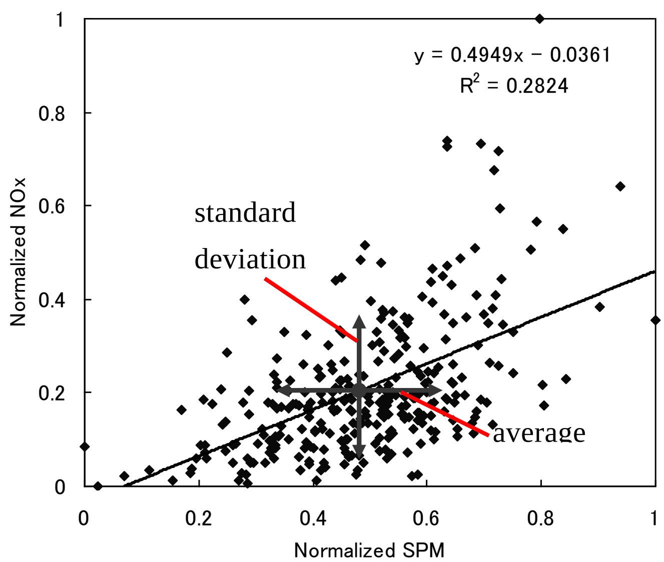

Figure 1. Correlation between SPM and NOx in year-round averaged values

Observation points were separated into two groups by K-L plot with the first and second principal components of PCA. Observation points in a group had small values of the first dominant component and large values of the second principal component. The SPM data in May and November demonstrated a different tendency by CA. CA showed almost the same tendency with PCA.

A mod-picture is shown in Figure 2. The power and mod-calculations of brightness of pixels show concentrated black stripes around the sun for the clear sky day. The black stripes are defined for the ideal Mie-scattering (Figure 2) When SPM flows into the atmosphere, the stripes are disordered, and SPM was observed close to the earth (Figure 2).

Figure ２. Remaining SPM projected by the sunset at July 9, 2007, 18:35 (JST), Nagareyama in Chiba prefecture, Japan.

The RGB values of the pixels were estimated. The ratios of B and G-brightness to R-brightness for the cross-section represented by the white line in Figure 3 are presented (Figure 4). Minimum points were observed at the middle part around at 1600-1800 for both B/R and G/R values. The minimum point reflects the existence of the high level of a concentrated smoggy haze, SPM.

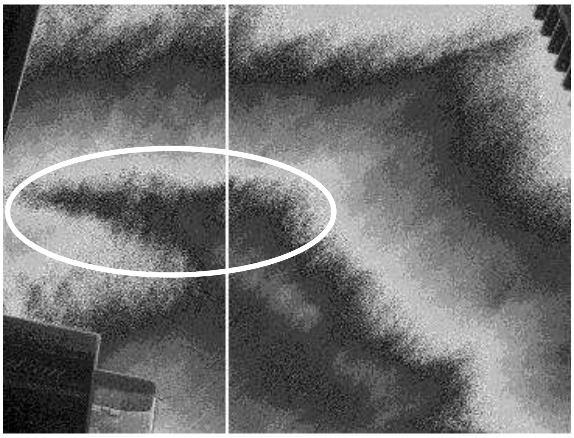

Figure3. Irregular distribution of the Mie-scattering at August 8, 2007, 09:06 (MST), Kuala Lumpur, Malaysia.

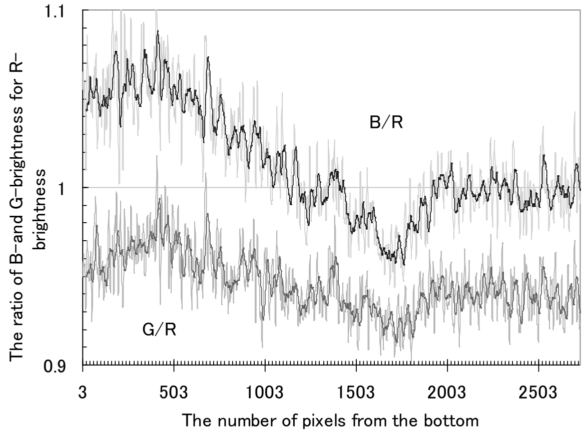

Figure 4. The ratio of B and G-brightness for R-brightness along with white line in Figure 3.

Furthermore, additional points were generated, and the amount of materials was estimated by CQSAR after learning of 31 observed data (Figure 5) taken at Seoul, Korea on April 13-14, 2008. The generated data were used for drawing a distribution map (Figure 6). Distribution map using the additional points generated by CQSAR is expected to be useful to understand the overview of material distributions.

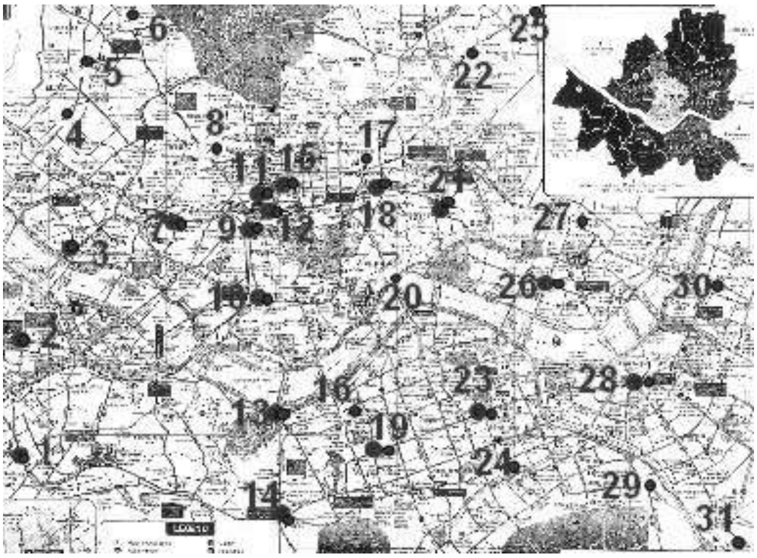

Figure 5. Observation points in Seoul

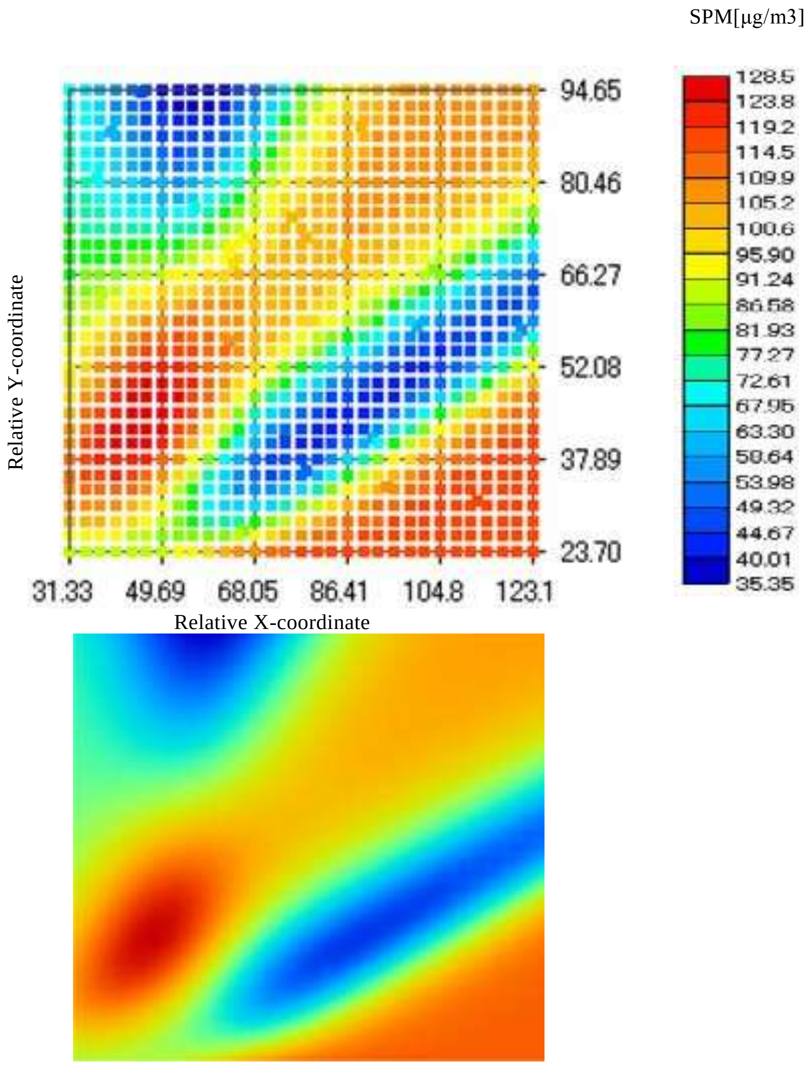

Figure 6. Distribution of estimated data and map

Air pollution in the eastern Asian mega cities is very serious problem for the human health care. We believe that SPM should be monitored as the human living environments. The detection of SPM is expected to be easier for the usual citizens. We proposed the visualized aerosol distributions in the atmosphere by commercial available digital cameras. The mod-pictures enable to show the SPM distribution in the air surrounding the local area, where the place for taken pictures, and also the RGB brightness is demonstrates the SPM characters.

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