OBSERVATION OF NO_2 AND O_3 DURING THUNDERSTORMS
(A Feasibility Study)

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ABSTRACT

The increase of NO_2 and O_3 concentration in total during thunderstorm have been reported by various workers. The average thunder day in a year for the area surround Indonesia is bigger than other. Hence for understanding the production mechanism and distribution of NO_2 and O_3 during thunderstorm, and also for understanding the increment of NO_2 and O_3 concentration due to the thunderstorms, the simultaneous observation throughout thunderstorm event is proposed.

INTRODUCTION

Ozone production and destruction processes are very much important for the study of sensitive issues such as O_3 depletion, green house warming, sea level rise etc. Those issues have been motivated some experts to perform several research about O_3 and using various instruments. Some workers also reported the increasing of NO_2 and O_3 concentration in the vicinity of thunderstorms. (Shlanta and Moore, 1972; Orville, 1967).

Indonesia as an area in tropical region, is one of the great lightning zone in the world besides Central of Africa and Amazon River, which have more than 120 thunder days average in a year as indicated form IKL (Isocheraunic Level) map of Indonesia as shown in Fig.1. (data observed on 1987). For its comparison, Japan has only 40-50 thunder days and mentioned data found only in several

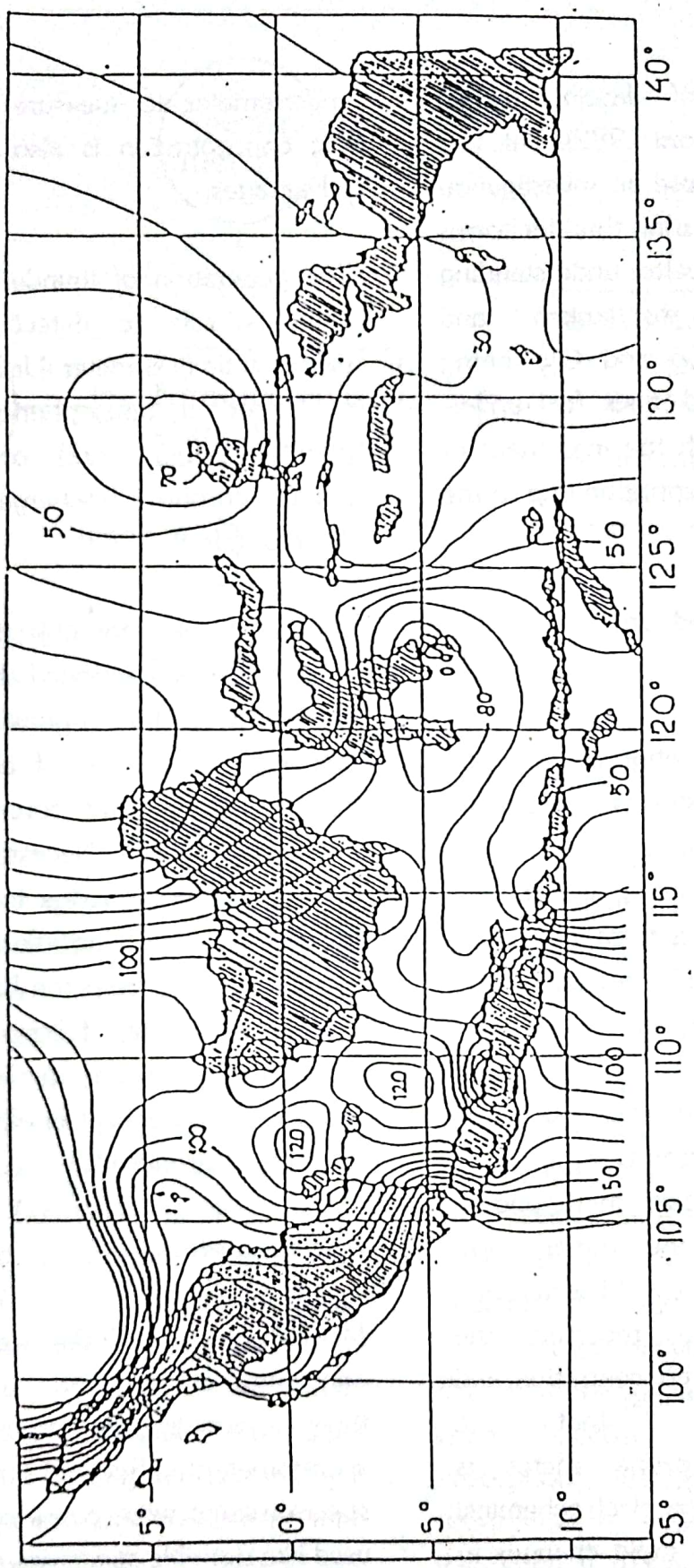

Fig.1 IKL map of Indonesia.

area of West of Japan, named Hokuriku Area, (Horii 1982). This fact motivated to propose an investigation of NO_2 and O_3 during thunderstorms for the interest of better understanding of production mechanism and distribution of NO_2 and O_3 during thunderstorms and also for understanding how much the increment of NO_2 and O_3 concentration due to the thunderstorms.

Proposed Method for Observation

Simultaneous observation of NO_2 and O_3 during thunderstorms is proposed by operating simultaneously a set of NO_2 and O_3 measuring instruments and a set of thunderstorm measuring detectors. Dufay (1949) measured O_3 by using slit spectrograph.

Orville (1967) measured by using slitless spectrograph. A chemiluminescent ozone meter and an electrochemical ozone meter were alternatively used by Shlanta and Moore (1972) to measure the atmospheric ozone concentration and finally decided that a chemiluminescent ozone meter is more responsive than electrochemical ozone meter to the rapid changes in ozon concentration that occur beneath thunderstorm. Noxon (1979) also reported that applying an optical spectrometer to measure NO_2 and O_3 concentration is also has many advantages.

The generation of thundercloud over head is able to detect by using electrostatic field meter (Uman, 1973), or a set of atmospheric potential monitor (ARA, 1992), or a set of point corona discharge current detector (Horii, 1982).

In order to reach the objectives of this observation as mentioned above, a set of spectrometer operates simultaneously with a set of electrostatic field meter or point corona current meter is proposed. Necessarily, a set of lightning flash counter to count the number of lightning flash around several distance from the base is also considered. The following block diagram of proposed method shown in Fig. 2. described briefly step of work being proposed..

Spectrometer

Measuring of NO_2 and O_3 concentration on the vicinity of thunderstorm is proposed by using a spectrometer. Several type of spectrometers were considered to be used like portable spectrometer, visible spectrometer, Brewer spectrometer etc. The proposed spectrometer is selected from the instruments which

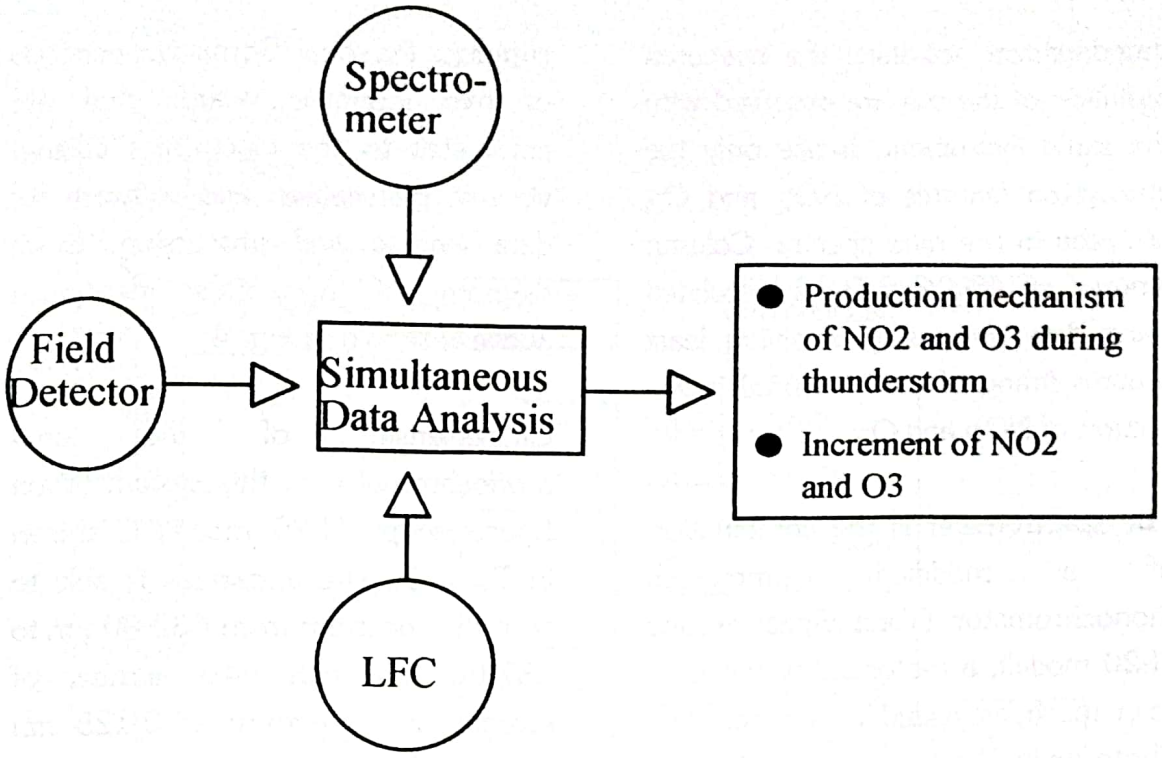

Fig 2. Block diagram of proposed method

available in LAPAN, such as the twilight zenith technique type spectrometer or Brewer type spectrometer. The first type spectrometer was installed in Ciater and the other in Watukosek. The new spectrometer from Brewer type will installed in Pontianak for the coming future. The spectrometer which was installed in Ciater contains of three major components; a zenith viewing spectrometer, an electronics cabinet and a personal computer with soft ware for data logging and processing. This system involves measuring the spectrum in the 440 nm region or scattered sunlight in the zenith sky during the twilight period everyday, and occasionally near mid day. Ratio of the spectrum obtained during twilight with noon time zenith day is observed as absorption spectrum of NO_2.

Observation method of Stratospheric NO_2 and O_3 with installation of electric field detector is shown in Fig. 3. The noon time zenith sky spectra is observed and is taken as a reference spectra. The zenith sky spectra during thunderstorm activities is ratioed with the reference spectra to determine the ratio spectra. The Fraunhofer absorption features and spectral distribution of solar spectra and the instrumental functions are eliminated in the ratio spectra, as during observation of noon time and at

thunderstorm activities, the scattered radiation of the sun are observed with the same instrument, hence only the absorption features of NO_2 and O_3 are seen in the ratio spectra. Column amount of NO_2 and O_3 is calculated using data processing involving least squares fitting of the measured cross-section of NO_2 and O_3.

The spectrometer is the combination of a modified commercial monochromator (Yvon Spectroscopy H-20 model), a motorized wavelength scan mechanism and a blue sensitive photo multiplier tube plus electronics. Electronics cabinet contains of a computer controlled EHT supply, a stepping motor driver, an analog input/output interface and power supplies. Personal Computer contains of two interface boards that are connected to the electronics cabinet via two plat cables, and software for data logging and processing. Block diagram of apparatus mentioned above is shown in Fig. 4.

Characteristic of the used monochromator in this system (Yvon Spectroscopy H-20 model) is shown in Table 1. The apparatus is able to scan the spectrum from 432.00 nm to 487.00 nm with 440 number of samples per spectrum at 0.125 nm spacing. the data is scanned 12 times with resolution 0.60 nm. Total time spent for completed scanning is 216 second.

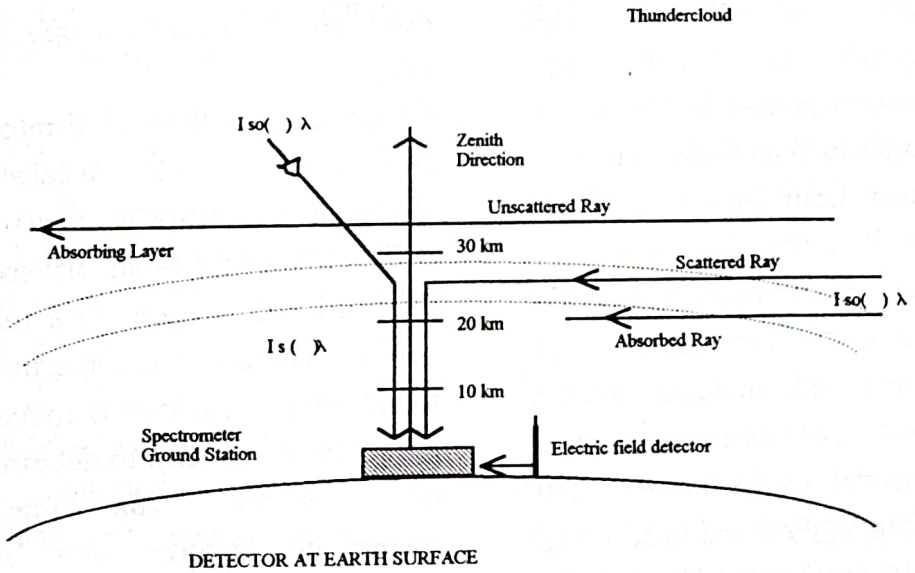

Fig. 3. Stratospheric NO_2 and O_3 Observation Method andInstallation of a set Electric Field Detector

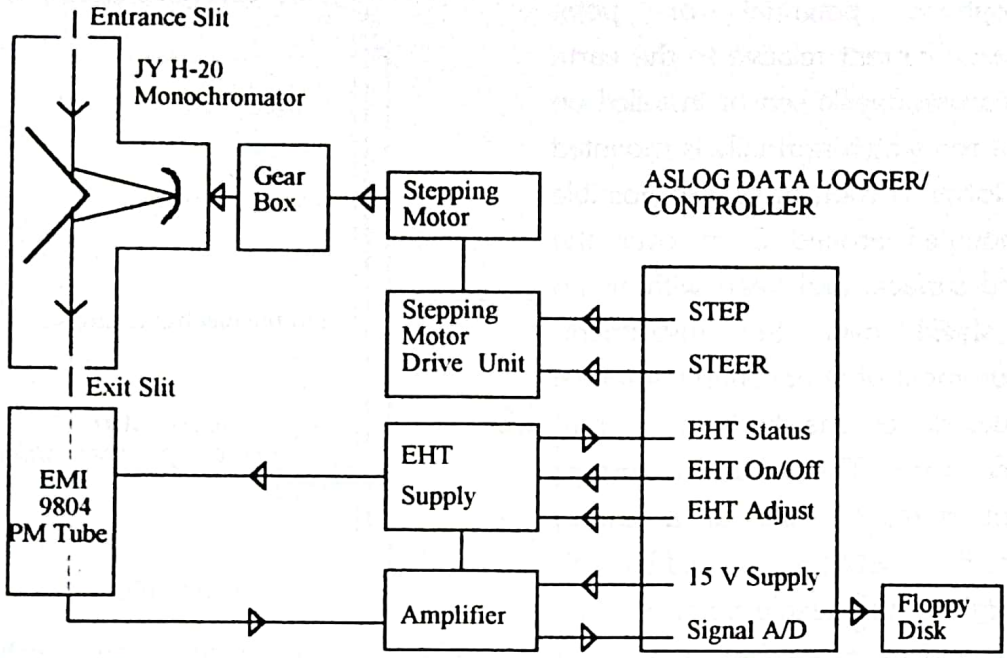

Fig. 4. Block Diagram of the Apparatus
Source : Technical Manual of the twilight zenith technique type spectrometer.

Table 1. Characteristic of H-20 Yvon Spectroscopy

Observed Spectrum Wavelength Range	432 - 487 [nm]
Region	0.60 [nm]
Focal Length	200 [mm]
Number of Grid	1200 [grid/mm]
Size of Slits	0.25 [mm] x 5 [mm]
Size of Grating	45 [mm] x 40 [mm]
Number of scan (Forward and Reverse)	12 times
Total time for scan	216 [seconds]

Source : Budiyono (1995), Private Communications.

Thunderstorm detector

When a thunderstorm approaches a location, its electric field which is 10 to more than 100 times larger than the normally present fair-weather field, causes the ambient field magnitude near the ground to rise from the normal fair-weather value of around 100 V/m to several 1000 V/m in a short period of time, depending on the speed of the storm's movement.

The electric field near the ground is able to be measured with an instrument named corona point discharge detector. This

instrumentation measures the atmospheric potential or point discharge current relative to the earth at a corona needle sensor installed on top of rod which normally is mounted on a tower or roof, or its also possible to mounted around 5 m over the ground surface, and keep without no any shield over the instrument. Measurement of atmospheric potential provides the corona discharge current or vice versa. The corona discharge current starts to flow at a critical electric field, which is changed by both the height of the needle point from he ground and radius of the curvature of the needle point.

An overview of the electric field detector or point discharge current detector is shown in Fig. 5. In this method, output of this unit is continued to recorder or to computer through A/D converter. The corona discharge current which flows from space charge through the needle and the potential difference will converted to electric field intensity over the ground surface.

Compare with other methods for measuring electric fields such as motor driven field mills, this method has important advantages as follows:

1. It has no moving parts and requires little maintenance compared to rotating machinery.

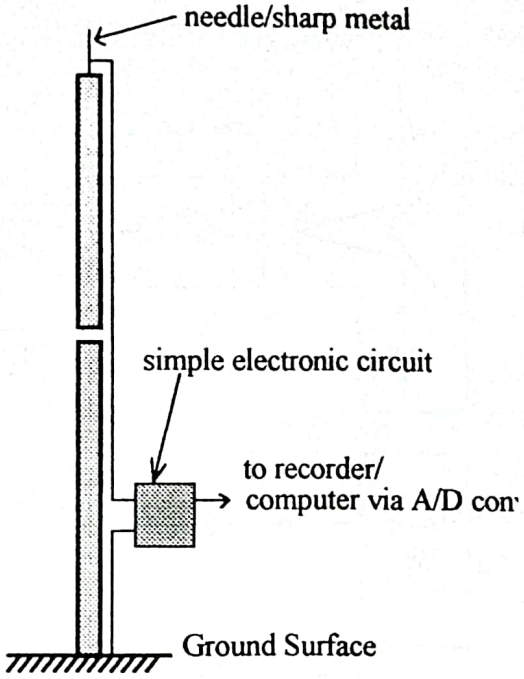

Fig. 5. An overview of point discharge current detector which functioned as an electric field detector during thunderstorm

2. It is unaffected by rain, snow, sand or insects, all of which can influence field mills.
3. The little weight sensor mounted easily, simple and power-sourceless.
4. Response of corona discharge current to electric field change is so quick, so that it is possible to detect fast change of electric field over head.

Long experiences have been provided the relation between the electric field intensity and the corona discharge current as shown in Fig. 6. The relation between the intensity of

electric filed near the ground to start the point discharge current and height of the point as shown in Fig. 7. (Horii, 1982).

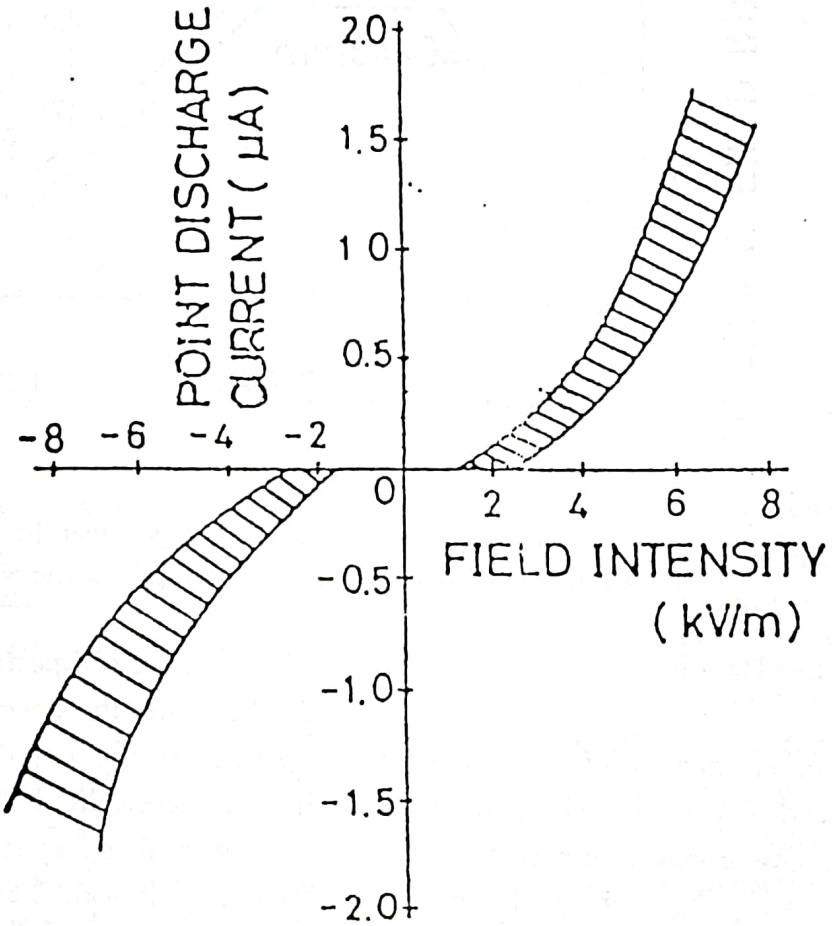

Fig. 6. Relation between the electric field intensity and the corona discharge current

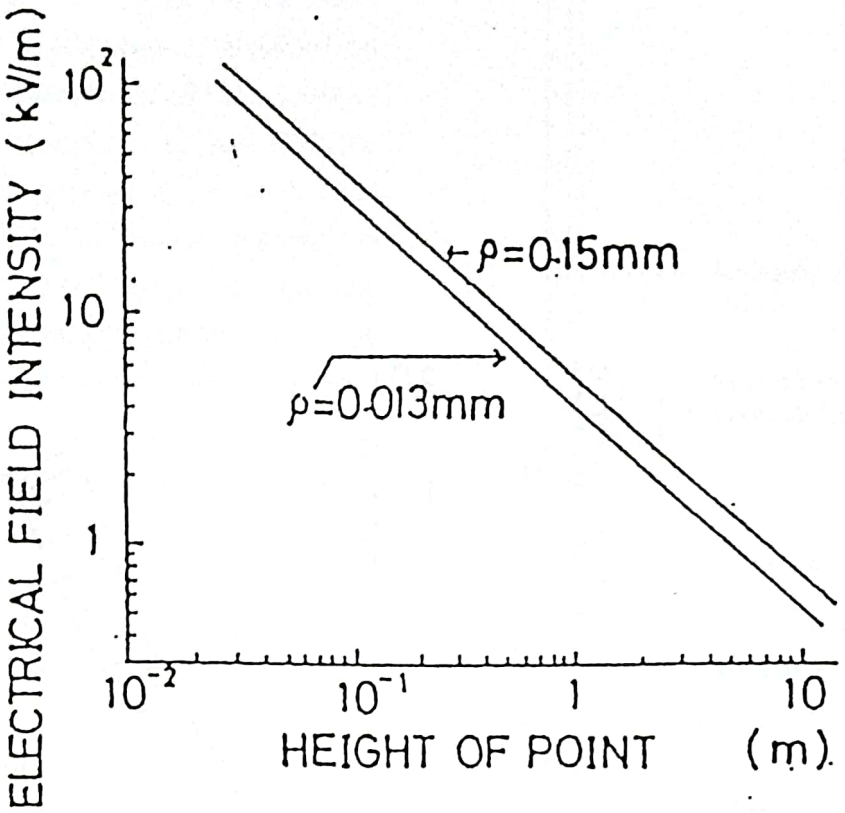

Fig. 7. Relation between the intensity of electric filed near the ground to start the point discharge current and height of the point

Expected Result

Observation method of Stratospheric NO_2 and O_3 explained in previous section give a description of the data which will be obtained during observation. Hence, the thunderstrom activities during observation periods will be presented by point corona discharge detector. Simultaneous observation of the instruments provide a similar observation time of receiving the spectrum and thunderstorm occurence.

Characteristic of Spectroscopy in Table 1. show that the spectrometer will be operated in the region of 432 - 487 nm for observation both NO_2 and O_3. The spectral region is scanned within 216 seconds with 0.60 nm resolution and data is recorded in hard disk or floppy disk. 440 samples with 0.125 nm spacing are selected from the observed ratio of the spectra during thunderstorm and noon time zenith sky spectra.

After several calculation using data processing involving least square fitting, output of systems, spectrometer set and electric field detector are strongly

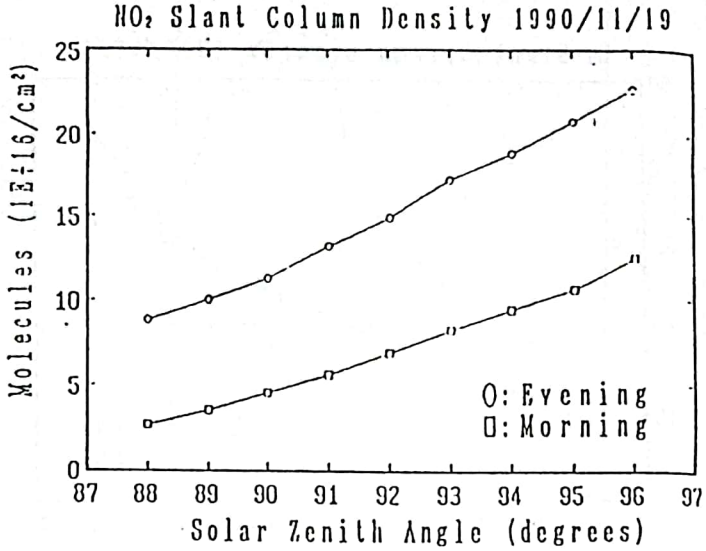

Fig. 8a. Plot of NO_2 slant column density observed in Japan using same instrument.

expected to be analyzed, and finally reach the objectives. The expected results to be useful for the satisfied analysis are pointed out as follows:

1. The changes of concentration in total of NO_2 and O_3 due to thunderstorm. For instance, the NO_2 and O_3 slant column density curve as similar as observed in Japan shown in Fig. 8a for NO_2 slant column density and Fig. 8b for O_3 colomn density are the type of data which is expected. In this case,the similar data observed during clear day dan during thunderstorm activities will be strongly expected to understand the influence of thunderstorm for NO_2 and O_3 concentration.
2. The relation of number of flashes per unit time near observation site obtained from electric field detector or lightning flash counter with NO_2 slant column density to understand how long the NO_2 will remain in the atmosphere after the occurence of lightning. Result of an observation in India to indicate the comparison of NO_2 slant column density observed by spectrometer and number of flashes per minute observed by electric field detector is taken as an example and is shown in Fig. 9.
3. The increment of total amount of NO_2 and O_3 due to thunderstorm activity is also interesting analyzing topic nowadays. By knowing the

number of flashes in a time period, the contribution produce of one flash for the increment of NO_2 and O_3 concentration will obtained.

second is The Aerospace Observational Facility of LAPAN has been operated Brewer Spectrometer in Watukosek, collaborates with NASDA of Japan. Besides that, in coming future LAPAN

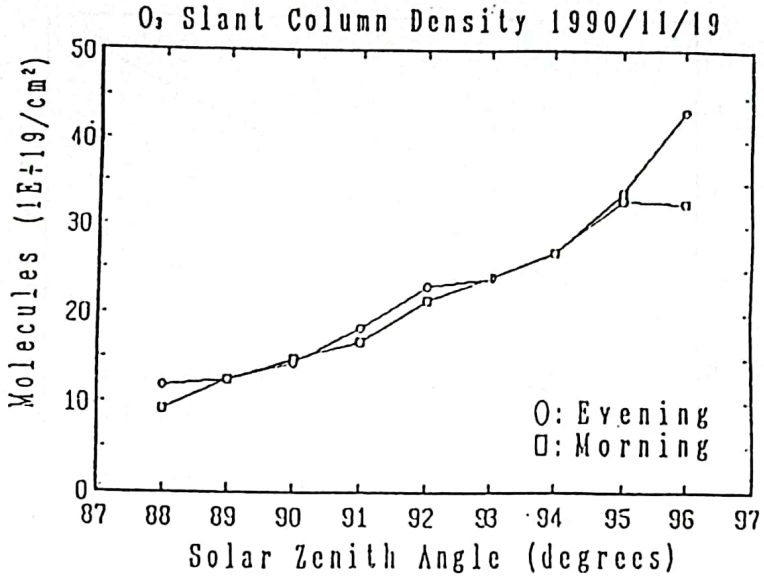

Fig 8b. Plot of O_3 slant column density observed in Japan

Concluding Remarks

The proposed method for simultaneous observation of NO_2 and O_3 during thunderstorm is taken as a feasibility study remembering that, presently LAPAN has a cooperation research using spectrometer with other institution from abroad. The first is, The Atmospheric Research and Development Center has been operated the Visible Spectrometer in Ciater, collaborates with Solar Terrestrial and Environment Laboratory of Nagoya University. The

will operate a set of Brewer Spectrometer in Pontianak. With three facilities above, we believe that this study will be able to performed and going on for the next future to give some profitable contribution for the progressing environment and climate research.

Finally, we believe that the simultaneous observation of the electrical parameter, NO_2 and O_3 and other gases during thunderstorm activities may give better understanding

regarding to their production mechanism during thunderstorm.

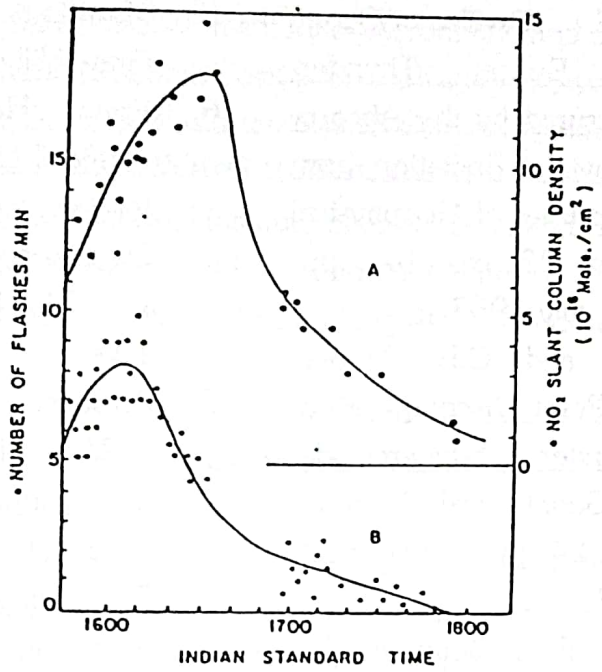

Fig. 9. Comparison of NO_2 slant column density observed by spectrometer and number of flashes per minute observed by electric field meter.

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