DEVELOPMENT OF TEMPERATURE AND HUMIDITY LIDAR FOR SENSING LOWER TROPOSPHERE

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ABSTRACT

We have developed a lidar system since 2001, which is for measuring temperature, humidity, and aerosol profiles up to 5km in five minutes. The system has been commercialized to the market. Applications of this lidar include monitoring of heat island phenomenon and environmental assessment etc.

1. INTRODUCTION

We have developed the lidar system for the measurement of temperature, humidity and aerosol up to 5km in lower Troposphere using ultraviolet laser in order to monitor heat island phenomenon and environmental assessment etc.

We have already completed two prototype models. One model was built up at University of Fukui in order to establish the Rayleigh scattering method for temperature measurement up to 5km with high accuracy and efficiency, and validated with radiosonde in summer of 2003. After this development, another model was build up at EKO instruments as an engineering type model in order to make the operation easier, faster, more precise, and more inexpensive. Those models could measure from 300m to 5km. Details are reported in [1].

On the other hand, rotational Raman scattering method for temperature was examined by latter engineering model. The Raman scattering temperature lidar could measure absolute temperature directly from 80m to 1km, and it could be used as a calibrator of Rayleigh scattering method that could measure relative temperature based on the specified altitude temperature. Details are reported in [2] and [3].

2. LIDAR SYSTEM

The external view of the lidar system is shown in Fig. 1. The lidar system is applied Rayleigh scattering method for temperature measurement, which has a high efficient system using single seeded laser and precise etalon filters, vibration Raman scattering method for water vapor measurement, and Mie scattering method for aerosol measurement. Specifications are listed in Table 1.

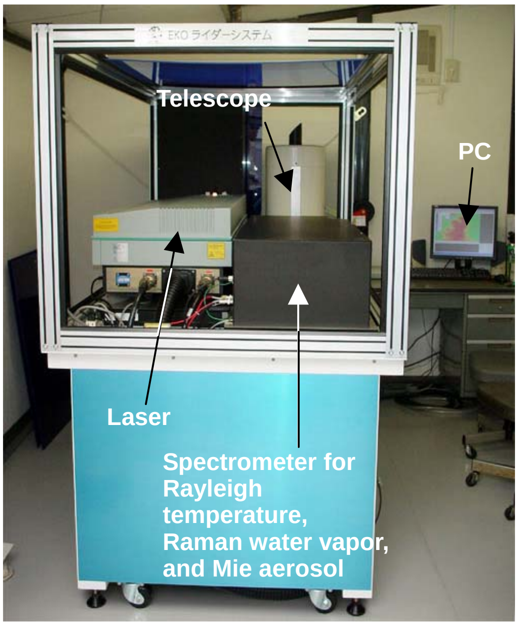

Fig. 1 External view of the engineering type model.

Tab. 1 Specifications of the lidar system for temperature and humidity

Item	Specifications
Laser system	Nd: YAG THG, Repetition: 20Hz, CWL: 355nm, Energy per pulse: maximum 300mJ Single seeded
Telescope	Diameter 250mm with UV coating, FOV: 1mrad
Main optics	Multi cavity etalon for Rayleigh and Mie scattering
A/D	40MSample/sec or 100 MSample/sec
Measured range	300m~5km
Range resolution	20m(lower height)～50m(higher height)
Averaging time	<5 minutes (6000shot)
Functions	Temperature, water-vapor density [g/m^3], relative humidity [%RH], scattering ratio, extinction coefficient, and lidar ratio

3. EXPERIMENTAL RESULTS

Comparison result of temperature profile of radiosonde and lidar is shown in Fig. 2, and it shows good fitting, and both techniques could be measure a temperature inversion layer from 2.3 to 2.7km.

Temperature measurements by this method were carried out in the center of Tokyo in summer and winter. The time series of temperature with altitude are shown in Fig. 2 and 3, and data conditions are shown in Table 2. In summer, a high temperature area was expanding to high altitude in the afternoon though temperature should become low as altitude became high in general. This would be an appearance of heat island phenomenon. On the other hand, in winter, temperature of upper air was lower than one of ground level, and layered structure of temperature was stabilized whole day.

4. SYSTEM APPLICATIONS

The goal of the lidar in the future is not only development of accurate measurement, but also is one of mobile lidar system with eye-safe. When the lidar is realized, scientific, governmental, and industrial customers can measure temperature and humidity of upper air in daytime and nighttime and at some severe conditions. Then present measurement methods; i.e. radiosonde, ground based weather stations including temperature sensor, and so on could be replaced to this lidar system in some cases.

Considerable applications are monitoring of urban climate change and environmental assessment etc. If the lidar adopts a lot of meteorological observatory, global warming could be also monitored.

REFERENCES

1. D. Hua et al, Development of UV Rayleigh scattering lidar system for measuring temperature profiles of the troposphere, JLSS abstracts of Papers, pp35-38, 2003.

2. K.Uchida et al, Measurements of temperature, humidity, and aerosol using Rayleigh/Raman lidar system, 23rd JLSS abstracts of Papers, pp159-162, 2004.

3. K.Uchida et al, Comparison result between rotational Raman lidar and radiosonde observation, 24th JLSS abstracts of Papers, pp85-88, 2005.

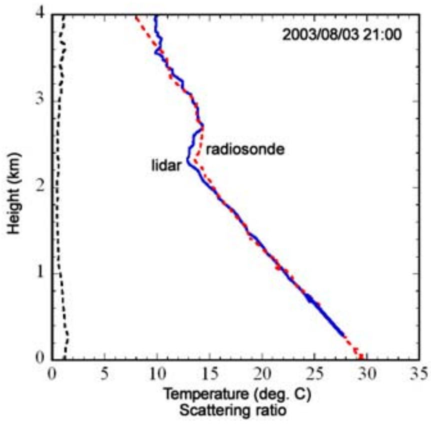

Fig. 2 Comparison result of temperature profile of radiosonde and lidar.

Table. 2 Data condition of graphs shown in Fig. 2 and 3.

Item	Fig. 1	Fig. 2
Time	2004/06/15 09:45~20:30	2005/02/04 09:00~19:15
Altitude range	0~2,500m	0~2,500m
Temperature range in color contrast	+5~+30 deg.C	-5~+10 deg.C

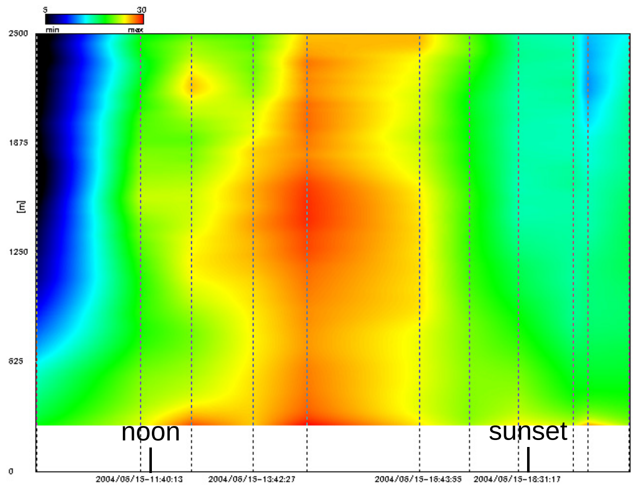

Fig. 3 Height distribution of temperature versus time measured by Rayleigh scattering lidar in summer.

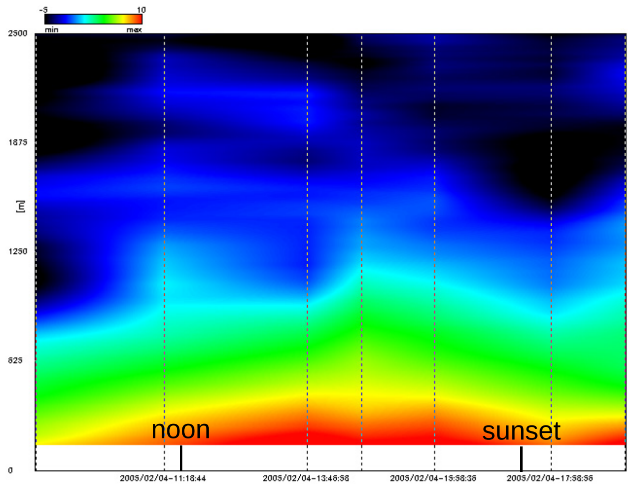

Fig. 4 Height distribution of temperature versus time measured by Rayleigh scattering lidar in winter.