5-2 Development of collaboration system for environmental study

AOKI Tetsuo, MIZUTANI Kohei, and ITABE Toshikazu

It is very important to collect various data in various places in the global environment study, which is one typical field requiring synthetic effort among various scientific disciplines. It is also important to carry out close collaboration with researchers in many research fields. We are developing a system realizing new concept, which enables us to share observation equipments, database, knowledge, etc., and thereby realizes a so-called multimedia virtual laboratory (MVL). In addition, the concept of MVL does not only mean in mere research and development activities, but also extensive applications in education, medicine, various telecommunications, is expected.

Keywords
Laser radar, Multimedia, Network

1 Introduction

Collaboration among a number of researchers is essential in global environment measurement. This is because the measurement sites involved are distributed over a wide range—in space as well as on the ground—and the required surveys must be carried out on a continuous basis, to enable monitoring of long-term changes in the global environment. It is thus almost impossible for a single research institute to perform satisfactory global observation.

It is expected that a virtually unified research center would be able to provide for sophisticated collaboration among different research facilities if researchers at remote locations were to share observation equipment, a database, and acquired knowledge via a high-speed communications network. This concept is referred to as the “multimedia virtual laboratory (MVL).” The Communications Research Laboratory began research and development on the establishment of MVL in 1997. Now, as part of this basic MVL research, investigations are underway at CRL concerning communication of three-dimensional observation data, the establishment of an MVL for a global environmental survey, upper atmospheric observation, and various temporal and spatial measurements involving multi-point large-capacity data sharing and real-time processing. Our lidar group, in the Applied Research and Standards Division, is involved in experiments relating to the establishment of an MVL for global environmental measurement, sharing observation equipment using lidar systems and developing an easy-to-use system for research meetings.

2 Objective of aerosol observation using lidar

In recent years, aerosols (microparticles in the air) have drawn attention as a key factor in global warming and ozone-layer depletion. While aerosols prevent warming by reflecting sunlight, they also contribute to the greenhouse effect in an indirect manner, as they form cloud cores, and chemical reactions on the aerosol surface affect the distribution of trace gases in the atmosphere. Thus it is very important to observe aerosols at ground sites at different altitudes on a continuous basis.

For example, we may gain a critical understanding of the life cycle of aerosols existing in a stable state in the stratosphere by determining the length of time the aerosols injected into the stratosphere during the eruption of Mt. Pinatubo[1]in the Philippines (June 1991) affect the Earth, when they will reach a stable state, how many of these particles will remain in the stratosphere, what the particle-size distribution will be and how the chemistry of the stratosphere will be. While it is possible to directly observe aerosol distribution with weather balloons, observation costs in this case are very high. At the moment, lidar (or laser lidar, equipment for observing the distribution of an object using laser light instead of radio waves) is the only affordable tool that allows for continuous monitoring. CRL has conducted continued aerosol observation following the installation of lidar systems worldwide—in Eureka (Canada), Alaska (in the Arctic Circle), Hokkaido (Japan), China, Thailand, India, and Indonesia, in collaboration with domestic and overseas research institutes. However, these lidar systems are operated by a small group of lidar researchers, where local co-researchers must maintain the installed measurement systems. Although Japanese researchers visit these sites periodically for backup purposes, these facilities face manpower-related difficulties leading to limitations in the duration of observation. It is therefore an ongoing challenge to raise lidar operability, to permit the acquisition of high-quality data on a continuous basis.

3 Fusion of a network and global environmental measurement technology

To perform continuous lidar observation from Hokkaido (a location well-suited to the observation of ozone-layer depletion), CRL installed a lidar system in Rikubetsu-cho, Ashoro-gun, in eastern Hokkaido in 1998, in collaboration with the Tohoku Institute of Technology[2][3]. At this location the sky is clear almost year-round and temperatures in winter are among the lowest in Japan (-30˚C). Using this facility as a launching pad, we are developing innovative lidar technology that will allow for remote system control via the Internet. We plan to apply this technology to other lidar stations, forming a lidar network equipped for automated observation. We have also developed a PC-based system that allows us to perform video conferencing, data sharing, and joint work at any time by linking remote researchers over a network. Through an organic combination of these two systems, we will be able to share observation equipment, data, and ideas, as if the various researchers in distant locations were all in the same office. This is the concept behind the multimedia virtual laboratory (MVL)[4].

4 Observation equipment

Table 1 shows the major specifications of the observation equipment; Fig. 1 represents a schematic diagram; and Fig.2 is a photo of the observation equipment installed in the Rikubetsu Astronomical Observatory. Since lidar is a device that detects weak light returned from gas molecules and microparticles in the atmosphere, a large-diameter telescope and a high-speed light detector capable of amplifying weak light signals are required.

Table 1 *Specifications of the aerosol lidar system*

Transmitter	
Laser	Nd:YAG double-wavelength (532 nm)
Output	150 mJ/pulse
Repetition	20 Hz
Beam divergence	0.1-m radian
Receiver	
Telescope	28-cm Schmidt-Cassegrain telescope
Coverage	2-m radian
Detector	Photomultiplier x 3
Height resolution	96 m
Observation parameters	Backscattering, Depolarization Ratio

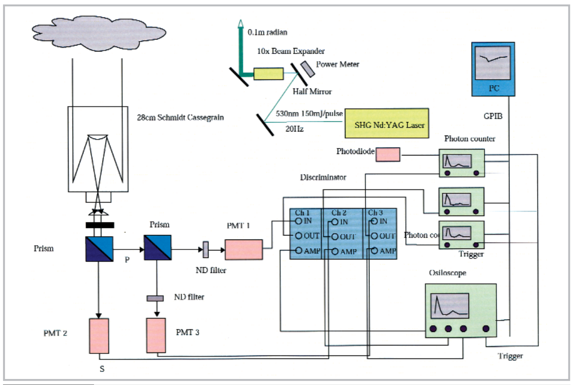


Fig.1 Block diagram of the lidar system

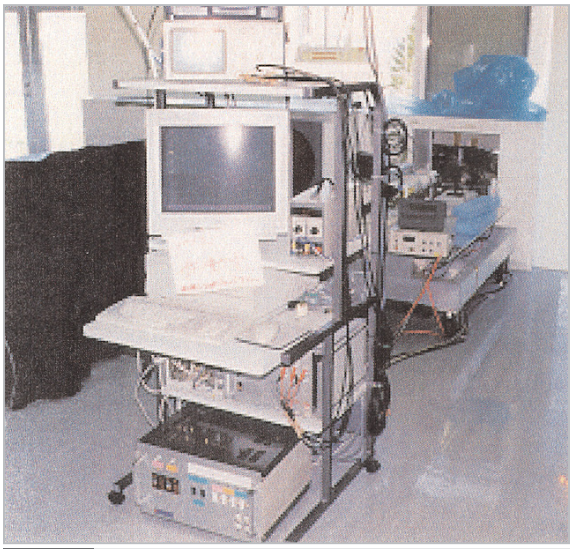


Fig.2 Aerosol lidar installed at Rikubetsu

5 Development of remote-control technology for lidar

In order to link remote laboratories and to enable them to work within a single system-one of the fundamental aspects of the virtual laboratory ; the researcher must be able to manipulate lidar systems installed at distant sites as if they were at hand and to acquire data as if the data were generated on-site. In the Rikubetsu laboratory, a network featuring a bandwidth of 1.5 Mbps has been installed. In addition, we have developed a server that remotely controls the observation equipment to open and close the telescope dome, monitor the facility with a camera, turn the high-output laser on and off, and adjust the optical axis. In the past, all of these tasks required on-site operation. This pioneering technology employs a lidar system equipped with a high-output laser that can measure aerosols up to the stratosphere. Since no comparable setup exists either in Japan or overseas, the system is currently receiving worldwide attention. Remote observation is carried out with reference to monitored video images provided by local weather observation equipments and remote cameras. Fig.3 and 4 show examples of the remote-observation control screen.

Fig.3 Remote-control screen for multiple-camera monitoring

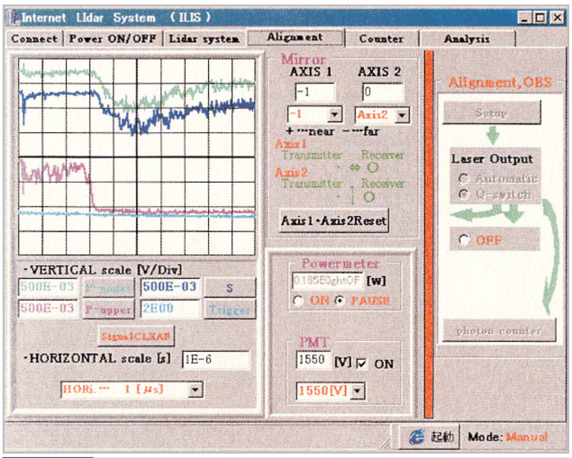


Fig.4 Remote-control screen

6 Multimedia conference system

Our new system provides researchers with a PC-based virtual research system that allows them to browse documents and talk to each other, taking notes, using their own desktop PCs and without leaving their regular offices. The whiteboard shared via network can display plain text, html text, jpeg and gif images, in addition to images captured by cameras installed on the PCs of other researchers located elsewhere. This information displayed on the whiteboard may be shared, thus, users may make changes to the objects it contains as they wish, working jointly as they simultaneously view images on-screen. Fig.5 presents an example of such a multimedia conference.

Fig.5 Demonstration of network conference

Currently, a system prototype is up and running that links the CRL (Rikubetsu, Koganei, Okinawa), the Tohoku Institute of Technology (Sendai), and Fukuoka University (Fukuoka). The system features a multi cast communication mode using tunneling, as these sites are linked by common Internet channels. In the future, there will be up to eight researchers in the link, conducting a program of observations and routine meetings, through which we will be able to estimate the necessary bandwidth and delay time of network. Furthermore, we have a plan to observe the atmosphere in winter using lidar, a particle counter, and millimeter-wave spectroscopy in the polar region in an investigation of the mechanisms of ozone-hole creation. In this context we will pursue a program of observation in which we will analyze and discuss the acquired observation data in on-line meetings, as we share simultaneous on-screen video images. This system is expected to pave the way for a new method of research for the network era, extending beyond the limits of conventional practices, with a significant resultant impact on research into the global environment.

7 Future challenges

We plan to replace the worldwide lidar systems installed and operated by the CRL Lidar Group with remote-controlled systems, using the Rikubetsu system as a model. Table 2 lists these lidar installation sites and the specifications of the proposed observation equipment.

Table 2 Summary of lidar systems installed worldwide

Site	Laser wavelength	Type of Lidar
Eureka (80N,86W)	1064nm,532nm	Mie(pol, A/D, PC)
PokerFlat (65N,147W)	532nm	Rayleigh
Wakkanai (45N,142E)	1064nm,532nm	Mie(pol, PC)
Rikubetsu (43N,144E)	532nm	Mie(pol, PC)
Lanzhou (36N,104E)	532nm	Mie(pol, A/D, PC)
Bangkok (13N,100E)	1064nm,532nm	Mie(pol, A/D, PC)
Tirupati (13N,79E)	532nm	Mie(pol, PC), Rayleigh
Bandung (7S,108E)	1064nm,532nm,355nm	Mie(pol, A/D,PC), Rayleigh Raman(N_2,H_2O)

Acknowledgments

We thank Professor Asai of the Tohoku Institute of Technology and Assistant Professor Hayashi of Fukuoka University for their useful advice. We also would like to express our appreciation to those at the Rikubetsu Astronomical Observatory in Rikubetsu-cho, Hokkaido, for making their observation site available.

References

1 T. Shibata, T. Itabe, K. Mizutani, K. Asai, "Pinatubo volcanic aerosols observed by lidar at Wakkanai",GEOPHYSICAL RESEARCH LETTERS,Vol.21, No.3, pp197-200, Feb. 1994.

2 T.Sugata, K.Asai, T.Aoki, K.Mizutani, T.Itabe, "Internet LIdar System (ILIS)", International Laser Sensing Symposium 99, pp135-136, 1999.

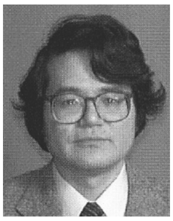
3 Tetsuo Aoki, Kohei Mizutani, Motoaki Yasui, Toshikazu Itabe, Kazuhiro Asai, "New Automated Lidar System and Multimedia Virtual Laboratory" , SPIE's Second International Asia-Pacific Symposium on Remote sensing of the Atmosphere, Environment, and Space", 2000.

4 Tetsuo Aoki, Kohei Mizutani, Kazuhiro Asai, "Environmental monitoring netwrok; Virtual Laboratory" , Japanese Journal of Optics vol29, PP554-555, 2000.

***AOKI Tetsuo**, Ph. D.*

Senior Researcher, Lidar Group, Applied Research and Standards Division

Optical Remote Sensing, Infrared Astronomy



***MIZUTANI Kohei**, Ph. D.*

Leadar, Lidar Group, Applied Research and Standards Division

Laser Remote Sensing

***ITABE Toshikazu**, Ph. D.*

Executive Director, Basic and Advanced Research Division

Laser Remote Sensing