S9-3 Validation and Science Application Plans for the Experimental Lidar In Space Equipment (ELISE)

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1. Introduction

Three-dimensional observation of the global distribution of clouds and aerosols is one of the most important means by which we can better understand the radiative processes related to climate change. Clouds have a large radiative effect that strongly depends on their vertical structure. Aerosols have a radiative effect directly through scattering and absorption, and they also have an indirect effect through the formation of clouds. However, we have insufficient knowledge of the distribution and the characteristics of aerosols, the processes of cloud formation, the vertical structure of clouds, and the radiative feedback of clouds and aerosols. Consequently, these processes are not dealt with precisely in climate models, which causes uncertainty in the model predictions. Space-borne lidars are among the most effective tools for observing the global distributions of clouds and aerosols and are useful for the validation of climate models and for process studies related to climate change.

The National Space Development Agency of Japan (NASDA) is developing the Experimental Lidar in Space Equipment (ELISE) for the Mission Demonstration Test Satellite-2 (MDS-2), which is to be launched in 2002.[1-3] The ELISE program has a two-fold objective. The first target is to demonstrate the technical feasibility of the key components and of the lidar system in space. The second target is to apply the observed data to scientific studies. In this paper, we describe an outline of the ELISE program and the plan for calibration, validation, and science application.

2. Outline of the ELISE System

ELISE is a two-wavelength Mie-scattering lidar (1053 nm and 527 nm) using a Nd:YLF laser. The receiver has three detection channels, an analog (AN) channel, a photon-counting (PC) channel at 1053 nm, and a PC channel at 527 nm. The planned orbit for ELISE is a polar orbit with an altitude of 550 km. The planned mission period is one year. The major specifications of ELISE are listed in Table 1. There are two operation modes for data acquisition: the high-resolution mode and the continuous operation mode. Horizontal resolution is 1.4 km (20-shot accumulation) for both the AN and the PC channels in the high-resolution mode. Because of the limitations in the data rate of the downlink available for the MDS-2, the duration of the observation period is limited in the high-resolution mode. In the continuous operation mode, observation can be continued with a horizontal resolution of 4.2 km (60 shots) for the AN channel and 21 km (300 shots) for the PC channels. Vertical resolution is 100 m for both modes.

3. Validation Experiment Plan

The validation of ELISE consists of two parts. The first part is the test of key components of ELISE and the calibration of the sensitivity of the ELISE system. The second part is the validation of the measurement of atmospheric parameters.

The ELISE system will be calibrated by a Rayleigh scattering signal from the atmosphere above 30 km. Because the air density is known from sonde data, etc., absolute sensitivity can be calibrated. A simulation study shows that this method can be applied to the 527 nm PC channel and to the 1053 nm PC channel. However, the sensitivity of the 1053 nm AN channel is too low to observe with Rayleigh scattering. This channel will be calibrated by comparing the signals of the PC channels for the same target with an appropriate backscattering coefficient. The measurement of atmospheric parameters will be validated by comparison with independent measurements. Plans include validation experiments using an airborne lidar and ground-based lidars. In the validation using an airborne lidar, the same target will be measured simultaneously with the airborne lidar and with ELISE. Ground-based lidars and ELISE will be compared statistically, using data collected over long periods.

Table 1 ELISE specification

Satellite		
	Orbit/height:	Circular (Sun-sync. polar) / 550±5 km
	Ground speed:	6.983 km/s
Transmitter		
	Laser:	LD-pumped Nd:YLF (fundamental and second harmonics)
	Output energy:	84 mJ at 1053 nm; 10 mJ at 527 nm
	Pulse repetition rate:	100 pps
	Beam divergence:	0.17 mrad (full angle)
Receiver		
	Effective diameter:	1000 mm
	Field of view (FOV):	0.21 mrad
Detector	Si-APD (analog detection and photon counting)	
	Quantum efficiency:	36 % (AN, 1053 nm)
	Detection probability:	1.5 % (PC, 1053 nm); 39 % (PC, 527 nm)
	Dynamic range:	AN: > 25 dB; PC: 4 Mcps
Measurement		
	Direction:	nadir
	Height coverage:	Earth surface to 35 km
	Vertical resolution:	100 m
	Horizontal resolution:	AN: 1.4 km; PC: 1.4 k (High-resolution mode)
		AN: 4.2 km; PC: 21 km (Continuous operation mode)

4. Science Application Plan

The targets of the observations will include the global distribution of cirrus and lower clouds, the layered structure of clouds, the distributions of tropospheric aerosols and stratospheric aerosols, and PSCs. Studies using ELISE data will include the following subjects:

1) Climatological analysis of cirrus clouds,
2) Climatological analysis of the vertical distribution and the multi-layered structure of clouds,
3) A study of radiation balance by simultaneous observation of clouds from the satellite and from the ground,
4) Studies of atmospheric circulation models, using the data of cloud distribution, cloud top height, and cloud structure,
5) Analysis of the three-dimensional wide-area distribution of aerosols in the troposphere,
6) Analysis of planetary boundary layer structures,
7) Analysis of the wide-area distribution of stratospheric aerosols and atmospheric circulation, and
8) Analysis of the polar stratospheric cloud.

Studies are currently being conducted at the National Institute for Environmental Studies (NIES) on data reduction algorithms and data utilization methods for space lidars. NIES and NASDA will cooperate in the ELISE program, based on a research agreement. The ELISE mission team will be formed under this research cooperation, and will include researchers from other organizations. NASDA and NIES plan to place Research Announcements for the validation experiments and researches conducted with the use of ELISE data.

References

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