Recent developments and results of NICT Doppler Wind LIDARs

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OUTLINE

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1. Introduction

- Coherent Doppler Lidar
  - Research and development of spaceborne coherent Doppler lidar.
    - Ground-based coherent Doppler lidar.
    - Airborne coherent Doppler lidar.
    - Eye-safe laser experiments for spaceborne system.
- Incoherent Doppler Lidar
  - Japan-US cooperative research projects (Alaska, US).

2. Coherent Doppler Lidar

- Study of computational algorithm for wind speed and wind direction (ground-based system, airborne system).
- Experimental study of coherent Doppler lidar from moving platform (airborne system).
- Accumulation of experience for the development of spaceborne system (airborne system).
- Developments of a half joule sub-scale laser for risk reduction and demonstration of spaceborne system.

Specifications of Coherent Doppler lidar

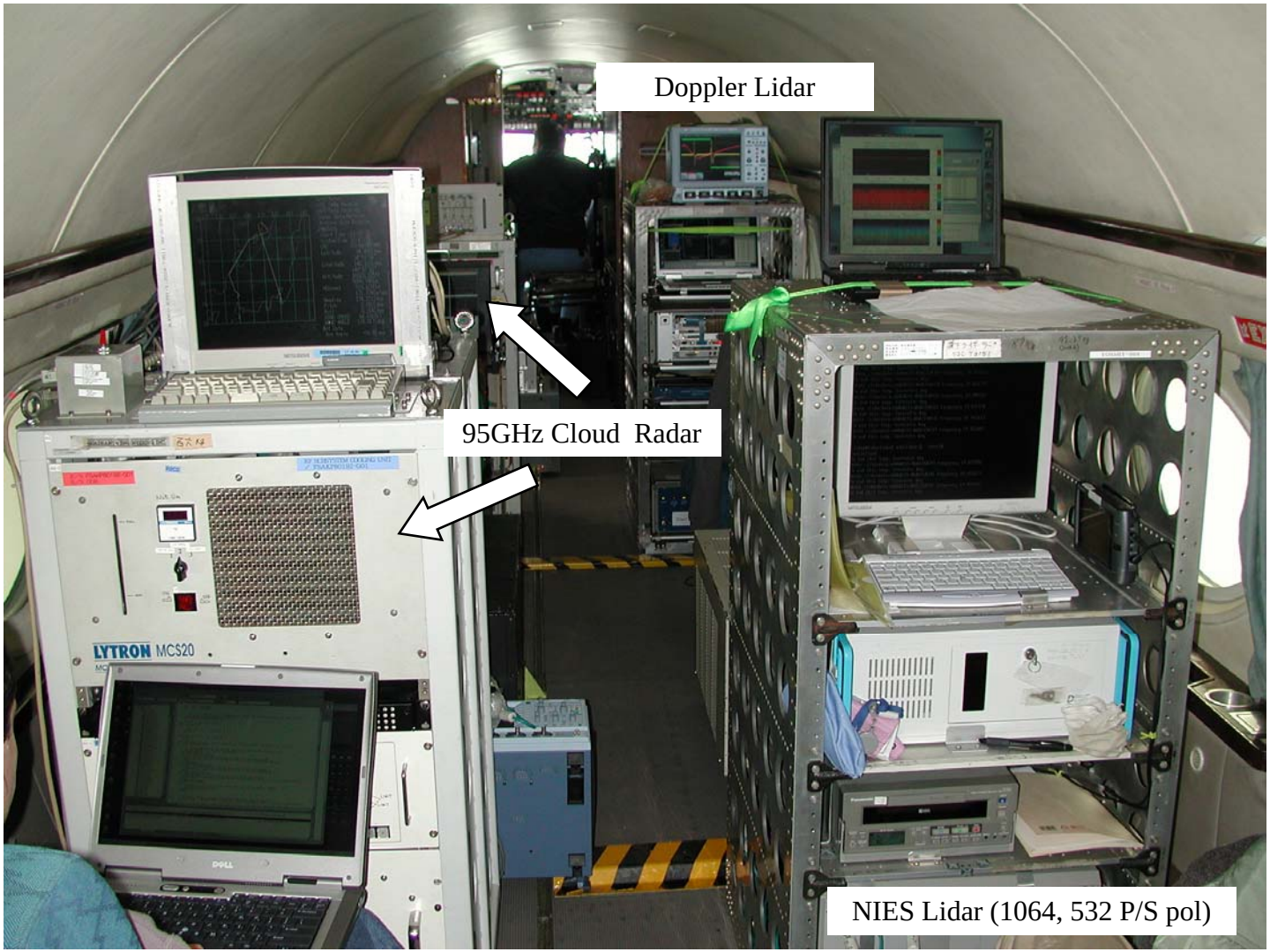
Transmitter and Receiver		Scanner and Signal processing		
			Ground-based system	Airborne system
Transmitter		**Scanner**		
Laser	Tm:YAG	Scanning axis	2	1
Wavelength	2.012 μm	Scanning elements	Mirror	Wedge prism
Pulse energy	7 mJ/pulse	Scanning range	AZ= -10-370°	AZ= 0-360°
Pulse width (FWHM)	560 ns		EL= -20-200°	EL= 70°
Pulse Repetition	100 Hz	Effective clear aperture	10 cm	10 cm
Polarization	Circular	Pointing accuracy	0.01°	0.1°
		Speed Ground-based mobile	20°/sec	5°/sec
Receiver		**Signal processing**		
Telescope diameter	10 cm	Resolution	8 Bit A/D	8 Bit A/D
Detector	InGaAs	Sampling frequency	500 MHz	100 MHz
		Data point	65536	8200
		FFT-point	256	64
		Range resolution	96 m	96 m
		Maximum range	19.6 km	12.3 km
		Minimum range	500 m	500 m
		Storage	500 GB HDD	16 GB HDD

Ground-Based/Mobile System

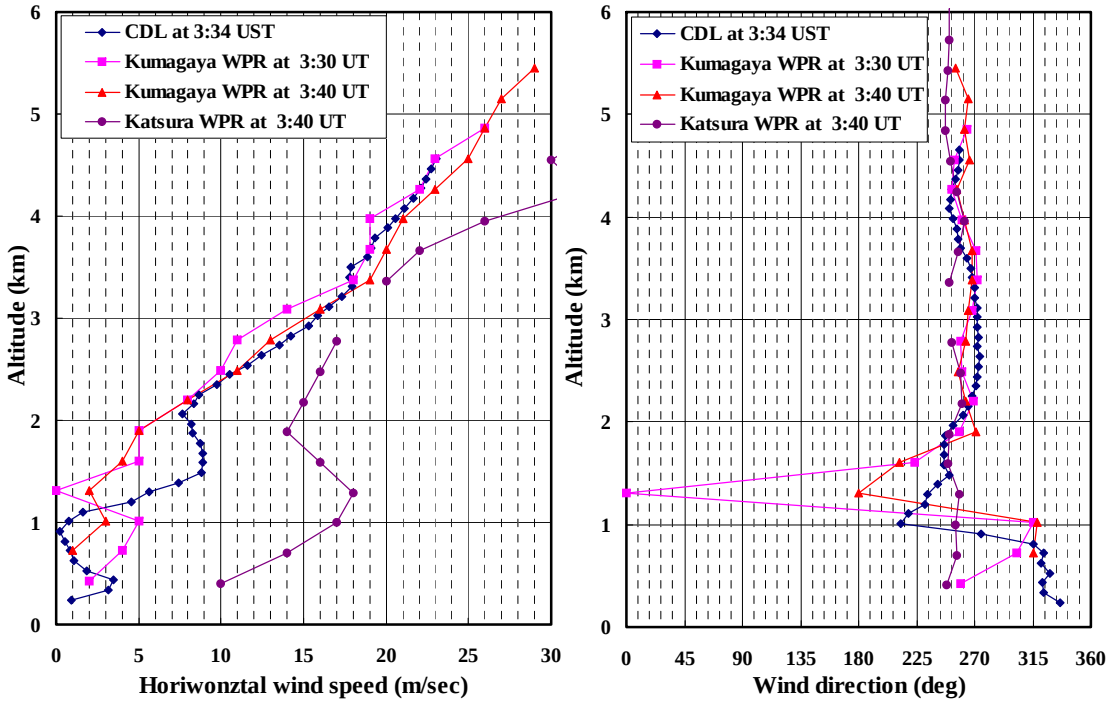
Research vehicle and cargo transporter

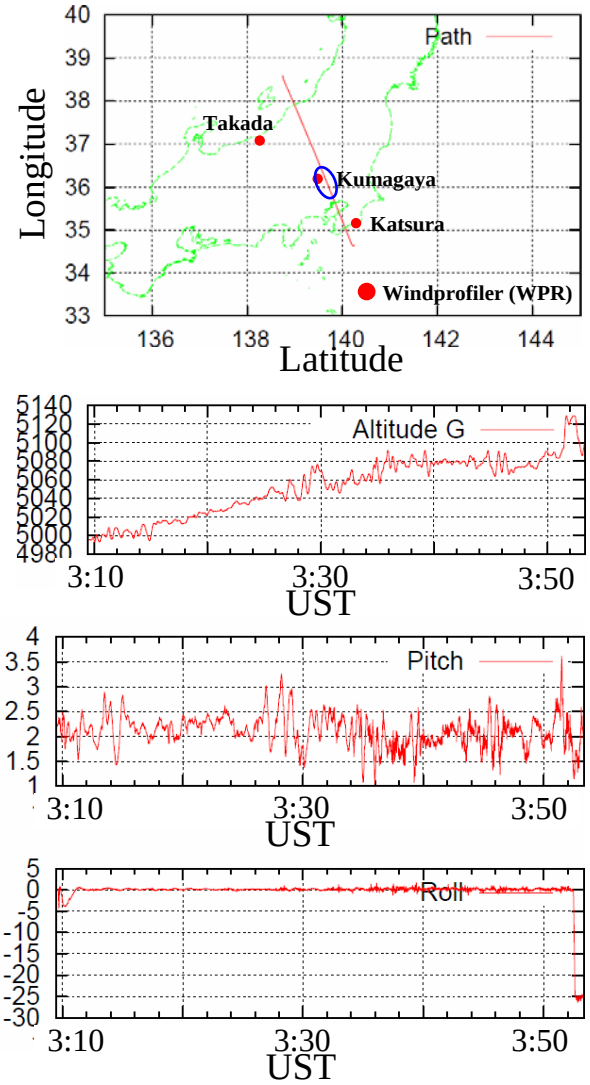
Inside the cargo space with the main body of the lidar colored blue

Airborne System



Airborne Experimental Results





Wind profiles measured by the airborne coherent Doppler lidar and the Windprofiler on February 15, 2006.

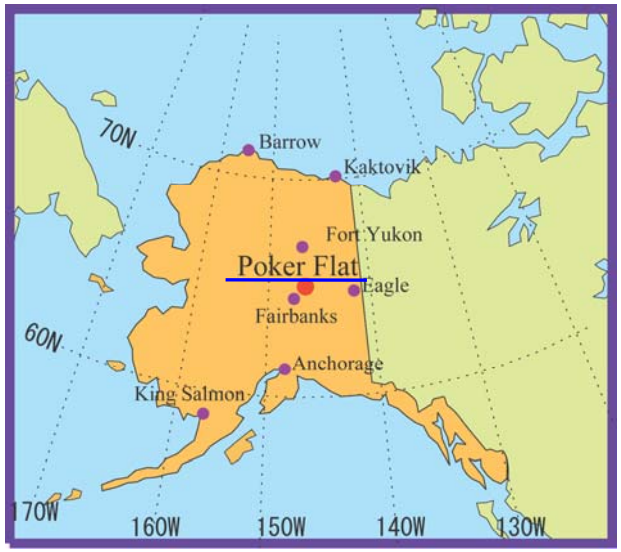
- 1500 laser pulse accumulation
- 9 directions (VAD)

3. Incoherent Doppler Lidar

NICT Lidar at Poker Flat, Alaska.

- Rayleigh Lidar (November 1997 -)
  - Structure and dynamics of the middle atmosphere.

- Multi-wavelength lidar (March 2003 -)
  - Aerosols, clouds and water vapor in the troposphere and stratosphere.



- Incoherent Doppler lidar (August 2005 -)
  - Wind in the stratosphere.

Specifications of Incoherent Doppler Lidar

Transmitter	
Laser	Nd:YAG (Injection seeding)
Wavelength	0.532 μm
Pulse energy	500 mJ/pulse
Pulse width (FWHM)	<8 ns
Pulse Repetition	30 Hz
Polarization	Linear pol
Divergence	<0.1 mrad

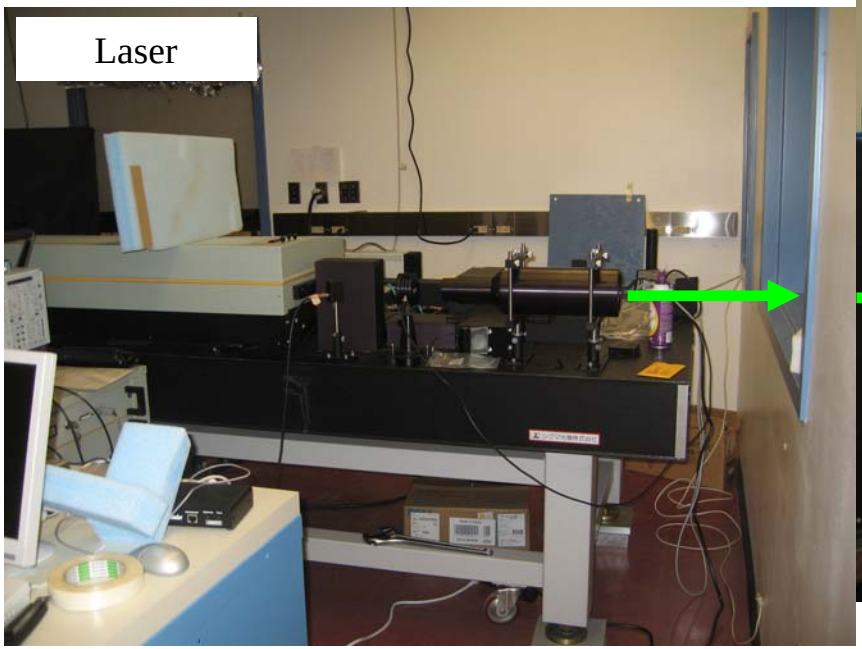
Telescope	
Diameter	75 cm
F number	3.7
Field of view	0.4 mrad

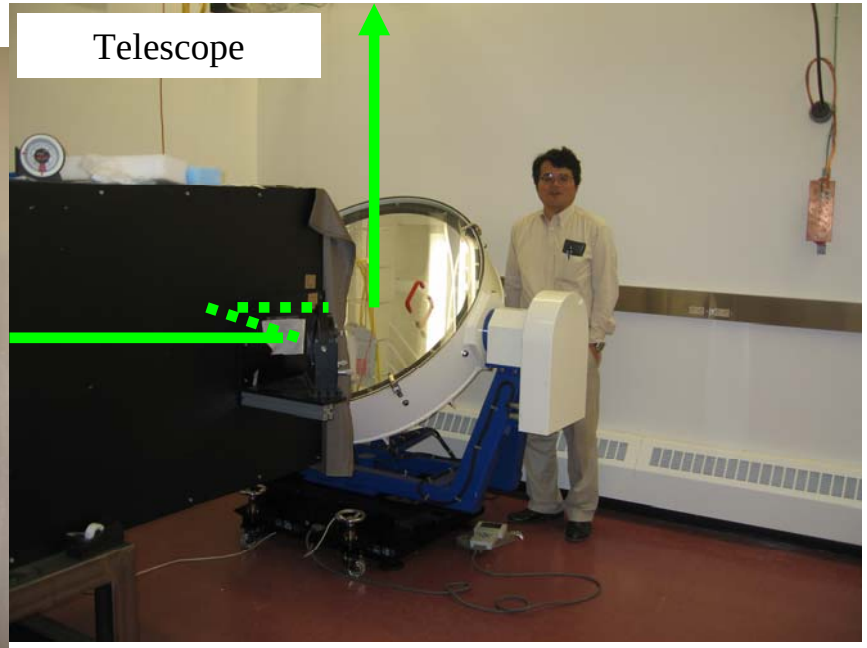
Fabry-Perot Interferometer	
Type	Capacitance-stabilized Etalon
Effective aperture	15 cm
Etalon gap	25mm
Free spectral range	6 GHz
Reflectivity	90 %

Detector	
Type	Equi-area ring detector
Channel	24 (300MHz/Ch)
Quantum efficiency	10 %

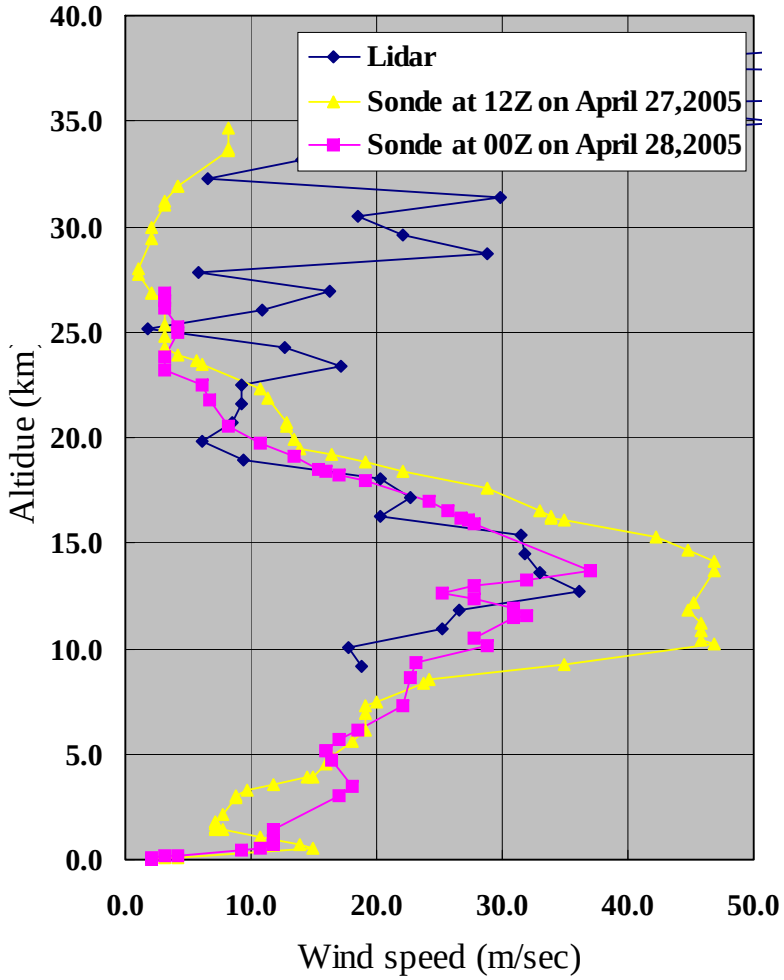
Signal processing	
Range resolution	196 m
I/O interface	GPIB

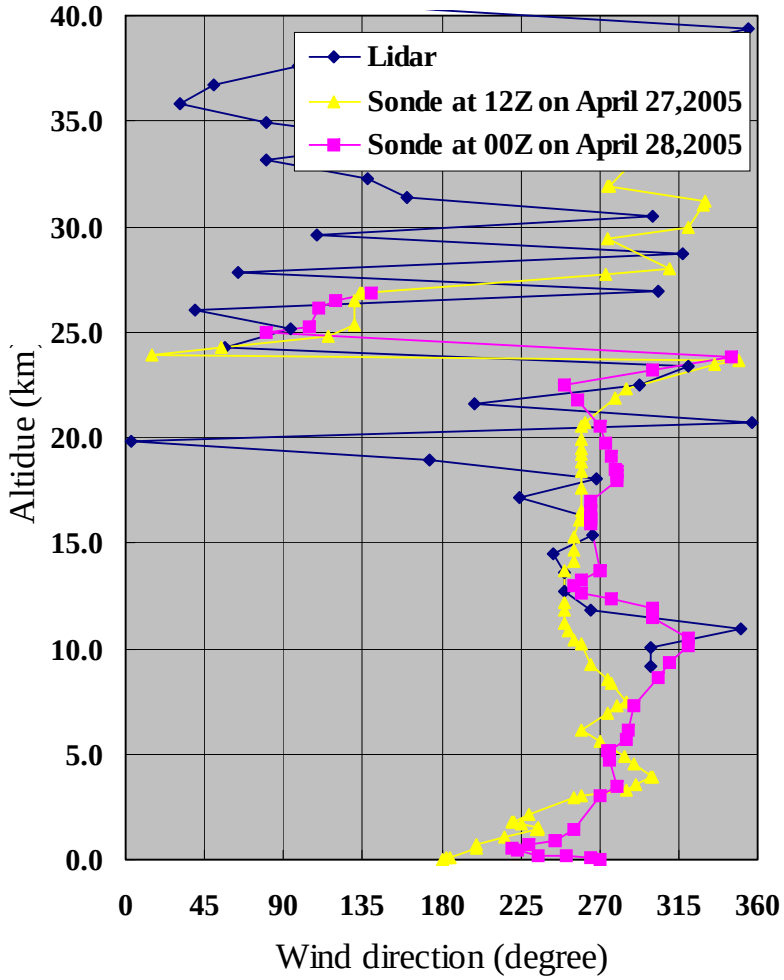
Block Diagram of Incoherent Doppler lidar





Experimental Result at NICT (Koganei, Tokyo)

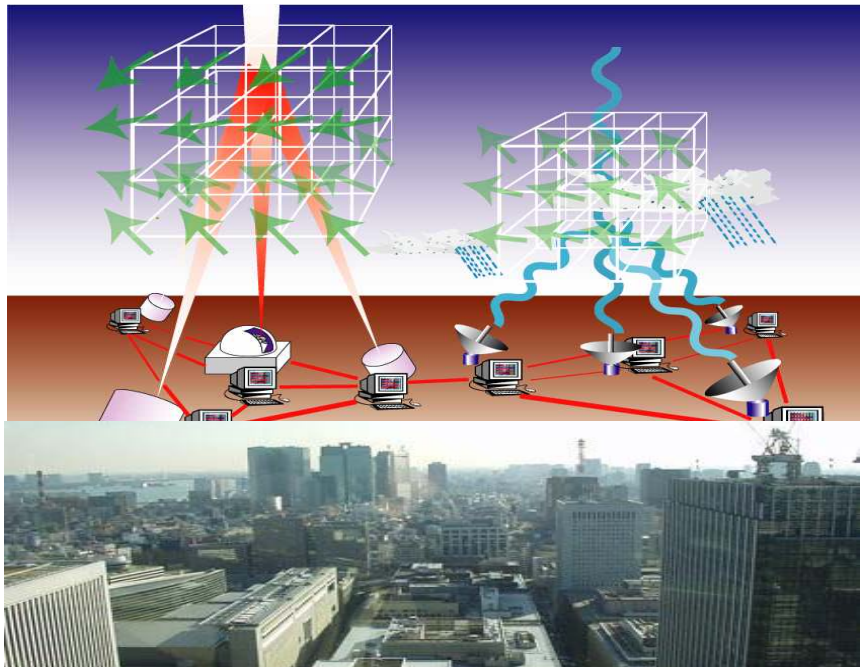


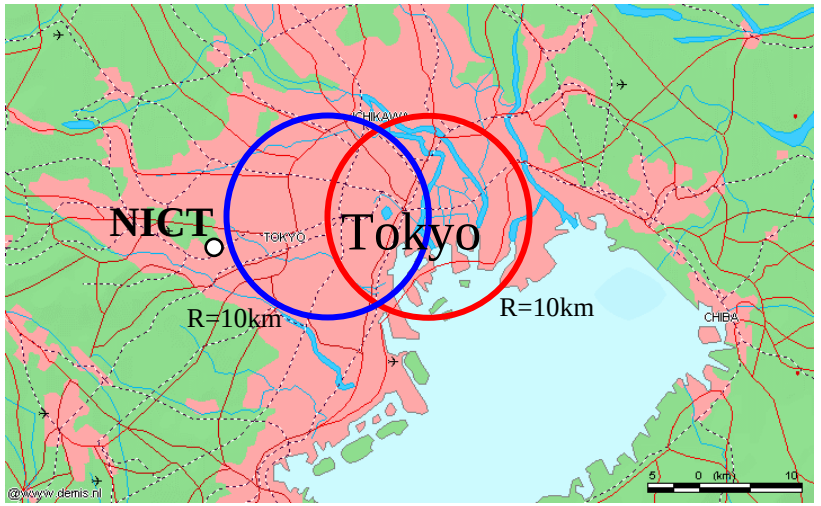


4. Current and future projects

➢Ground-based coherent Doppler lidar.

- Diversion of Tm,Ho:YLF sub-scale laser from spaceborne system to ground-based system (50-100 mJ, 20-30 Hz).
- Sensing network project (urban area of Tokyo).
  - ◆ Coherent Doppler lidars, Windprofiler (1.3 GHz).

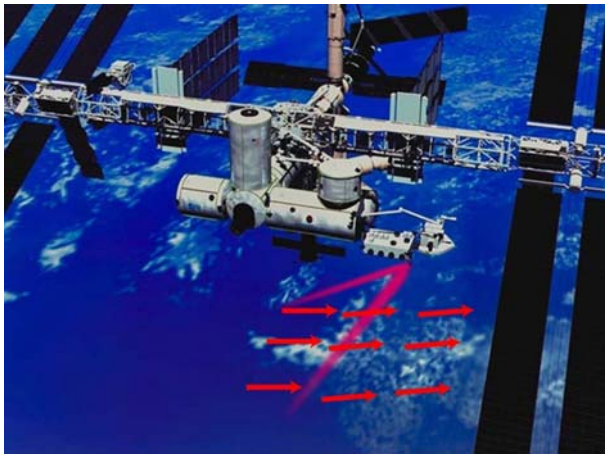




➢Spaceborne coherent Doppler lidar.

- Tm,Ho:YLF sub-scale laser experiments for the ISS-JEM/CDL (2J, 10Hz).
  - ◆ Slave OSC (6mJ, 10Hz) ➞ End pump AMP(100mJ, 10Hz) ➞ Side pump AMP(500mJ, 10Hz).
- ISS-JEM/CDL.
  - ◆ Review of medium- and long-term programs (JAXA).
  - ◆ Free flyer (500mJ+40cmΦ) or Small satellite (500mJ+40cmΦ).
  - ◆ One of the candidates for the optical remote-sensing satellite (?).

NICT(and JAXA) 2μm Coherent Doppler lidar



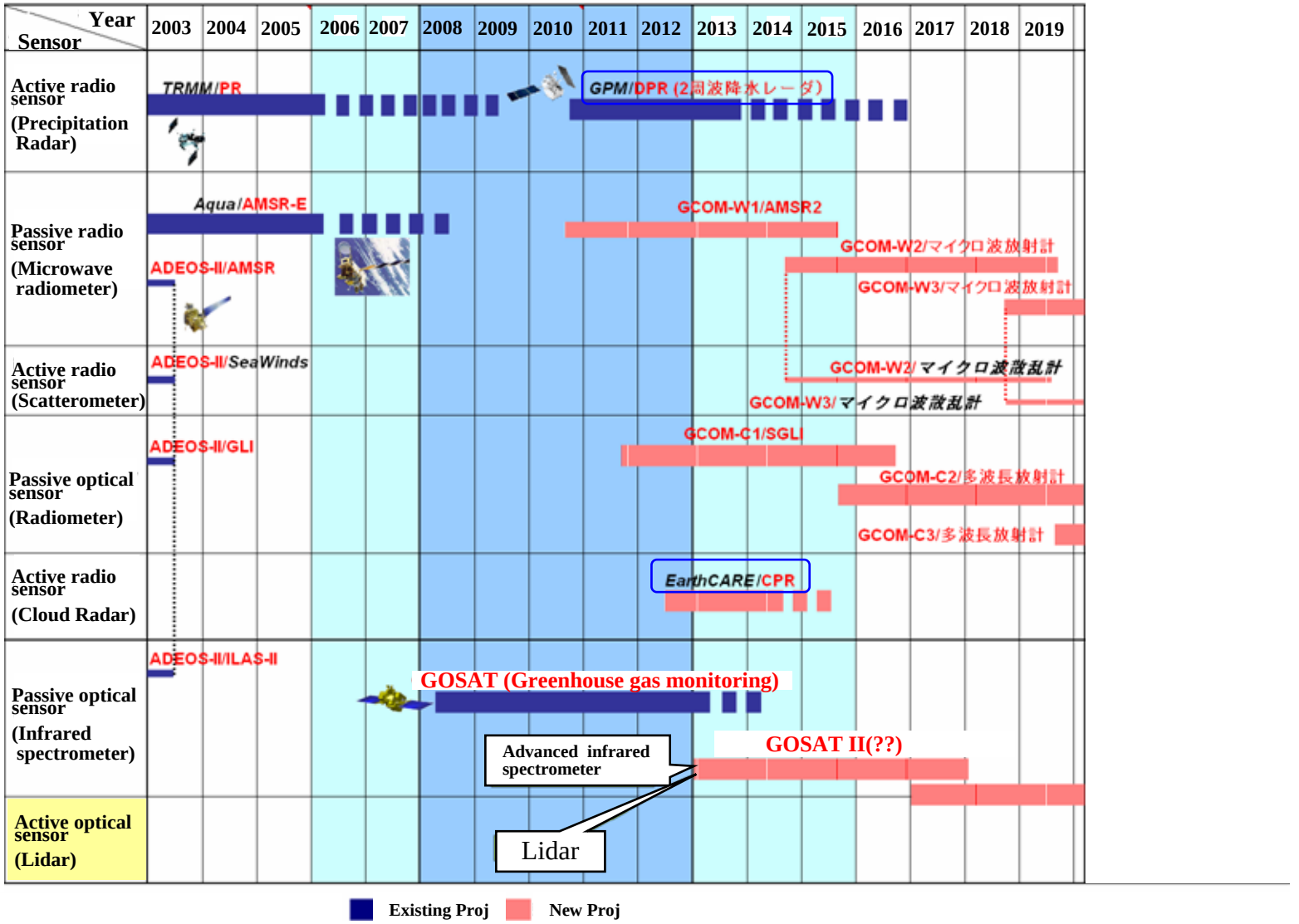
JEM/CDL

500mJ+40cmΦ Free flyer
feasibility/availability/operational

or

200mJ+20cmΦ Small satellite
feasibility study

Global environmental monitoring program



5. Summary

- Airborne experiments were made to demonstrate the feasibility of the coherent Doppler lidar from moving platform in 2004 and 2006.
- Wind profiles were successfully obtained from the surface to the altitude of up to about 7 km. The results obtained by the airborne coherent Doppler lidar were agreement with those measured by other instruments.
- NICT Doppler lidars (and 95GHz cloud radar) can contribute to the the validation of the ADM-Aeolus.
- Moderate output conductive cooled, 2μm solid-state lasers is developed for ground-based and airborne Doppler lidars and a differential absorption lidar.
- Development of high pulse energy and high efficiency eye-safe laser for space applications will be continued:
  - Contribution to R&D of airborne and ground-based/mobile Doppler lidar.
  - Study of measurement of wind, CO_2 and H_2O (DIAL) with spaceborne coherent lidar.