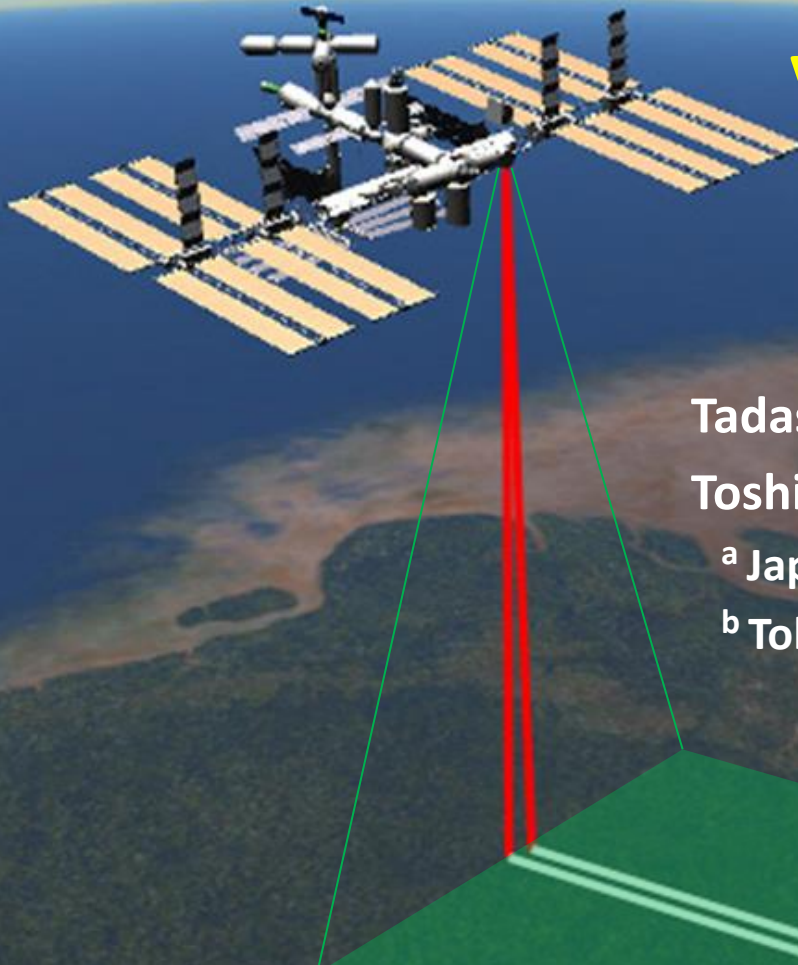


The Status of Vegetation Lidar MOLI

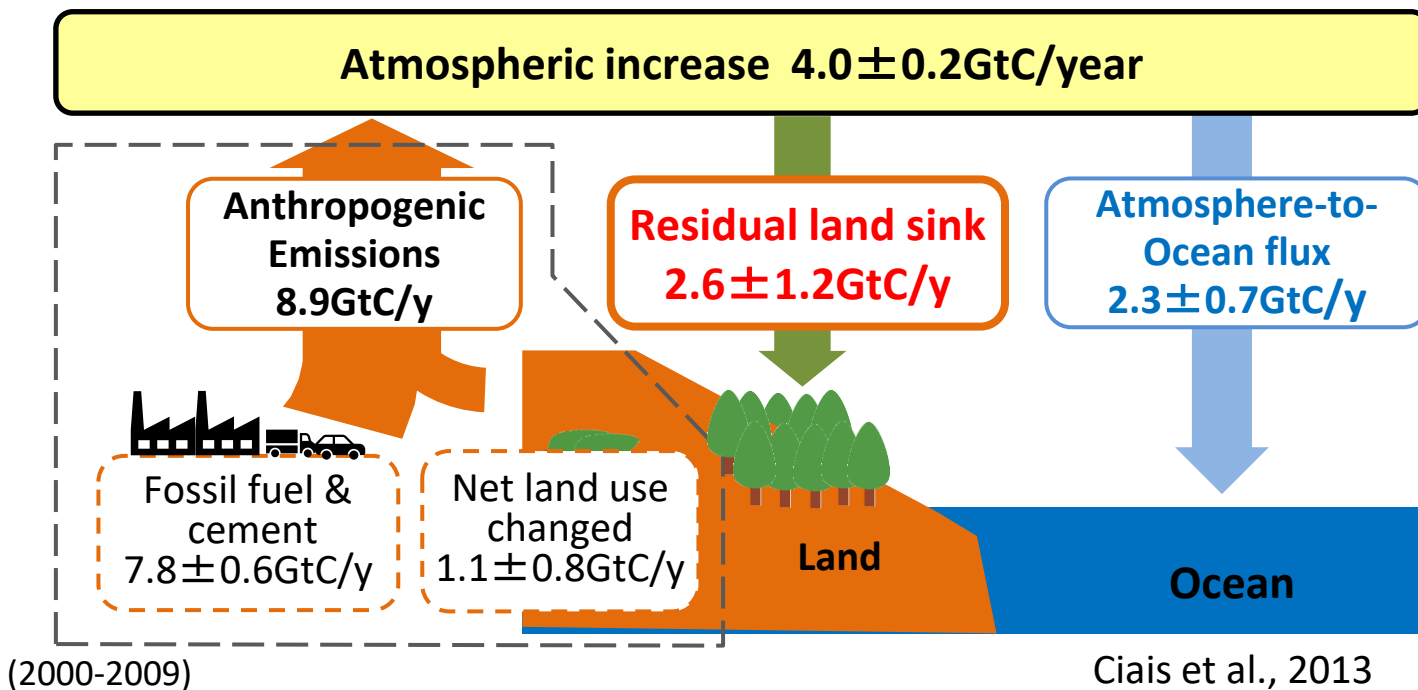
A diagram illustrating the MOLI (Molecular Oxygen Lidar) system. It shows a satellite in orbit above a forested landscape. A red laser beam is emitted from the satellite, forming a narrow cone that hits the ground. A green rectangular area on the ground represents the footprint of the laser. The background shows a view of Earth from space, with a blue sky and a dark horizon.

Tadashi Imai^a, Rei Mitsuhashi^a, Daisuke Sakaizawa^a,
Toshiyoshi Kimura^{a*}, Kazuhiro Asai^b

^a Japan Aerospace Exploration Agency (JAXA)

^b Tohoku Institute of Technology

- Terrestrial carbon budget due to land use change and carbon absorption by forests are more uncertain than others. (Ciais et al., 2013) The uncertainty is mainly caused by difficulty of measuring forests globally.
- Lidar can observe precise canopy height and biomass and we could estimate global forest biomass using data fusion of lidar, Imager and SAR data.
- High-precision forest biomass data will reduce the uncertainty of forest sinks and contribute to a better understanding of the carbon cycle.



- **MOLI** (Multi-footprint Observation Lidar and Imager)

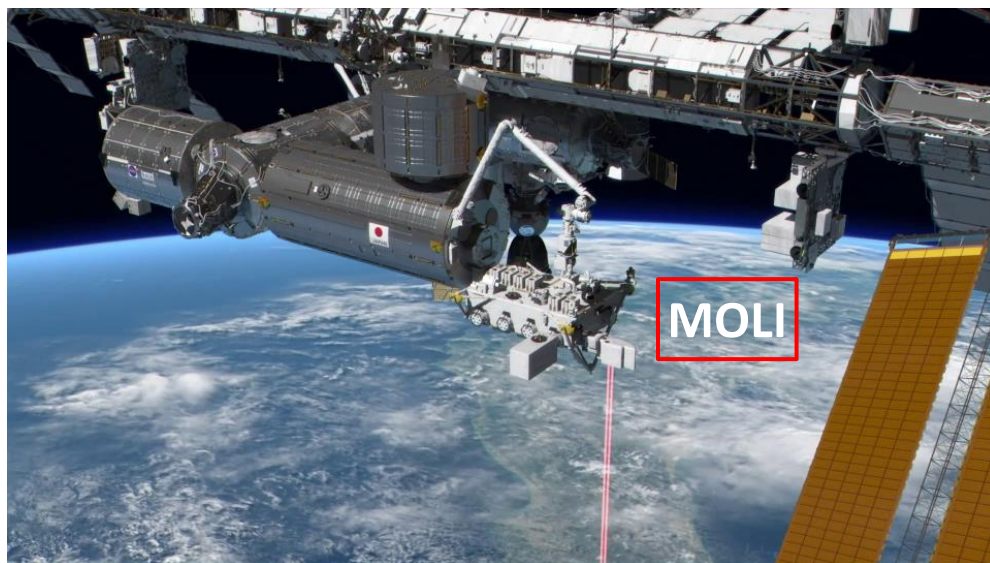
- Installed on ISS JEM-EF
- Orbit : ISS orbit
 - ✓ Non-sun-synchronous
 - ✓ Inclination : 51.6 deg
 - ✓ Altitude : about 400 km

- **Sensors**

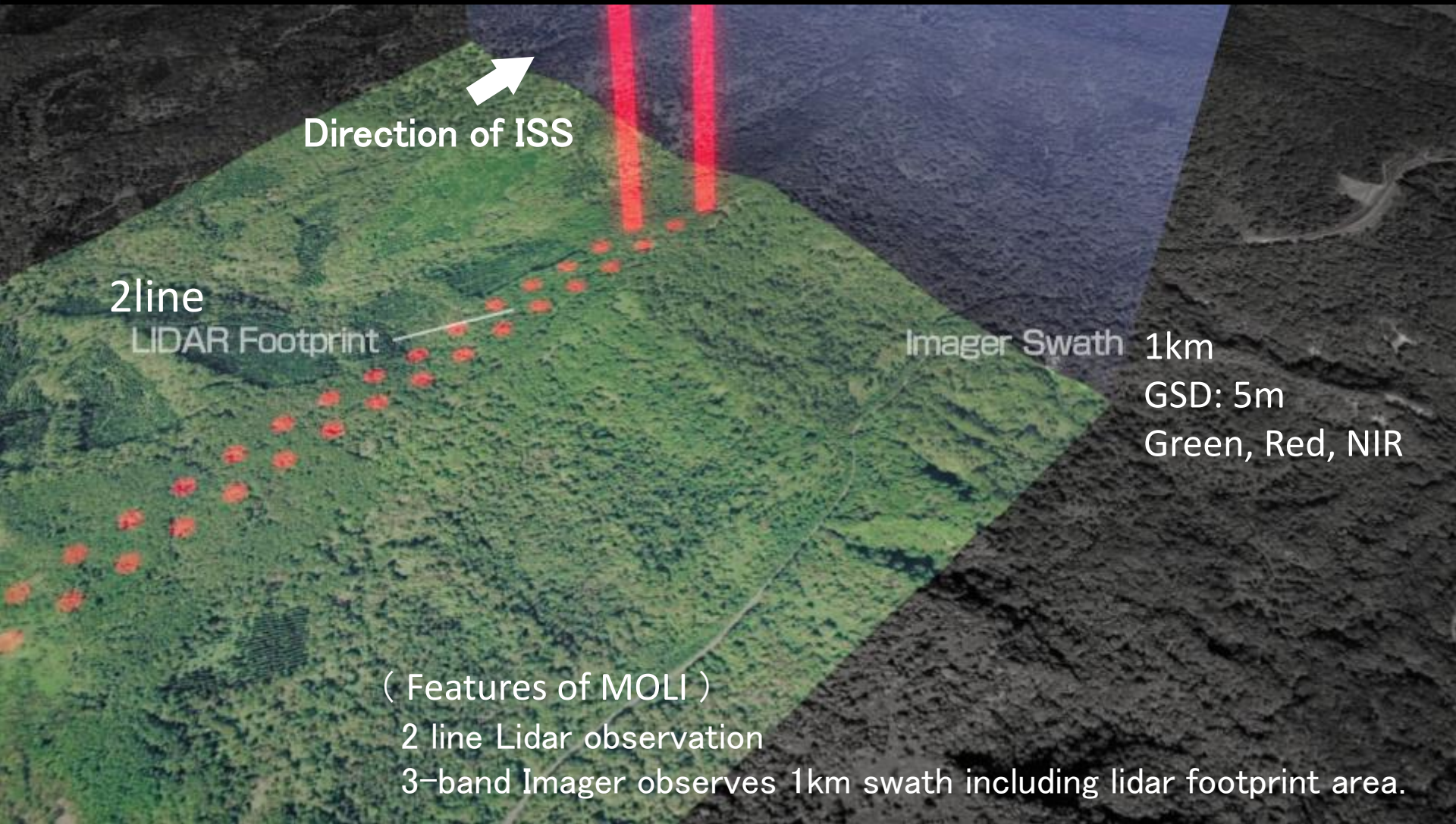
- LIDAR (1 μ m, multi footprint)
- Imager(Green, Red, NIR)
 - ✓ GSD:5m, swath : 1km

- **Launcher**

- Target launch : JFY 2024

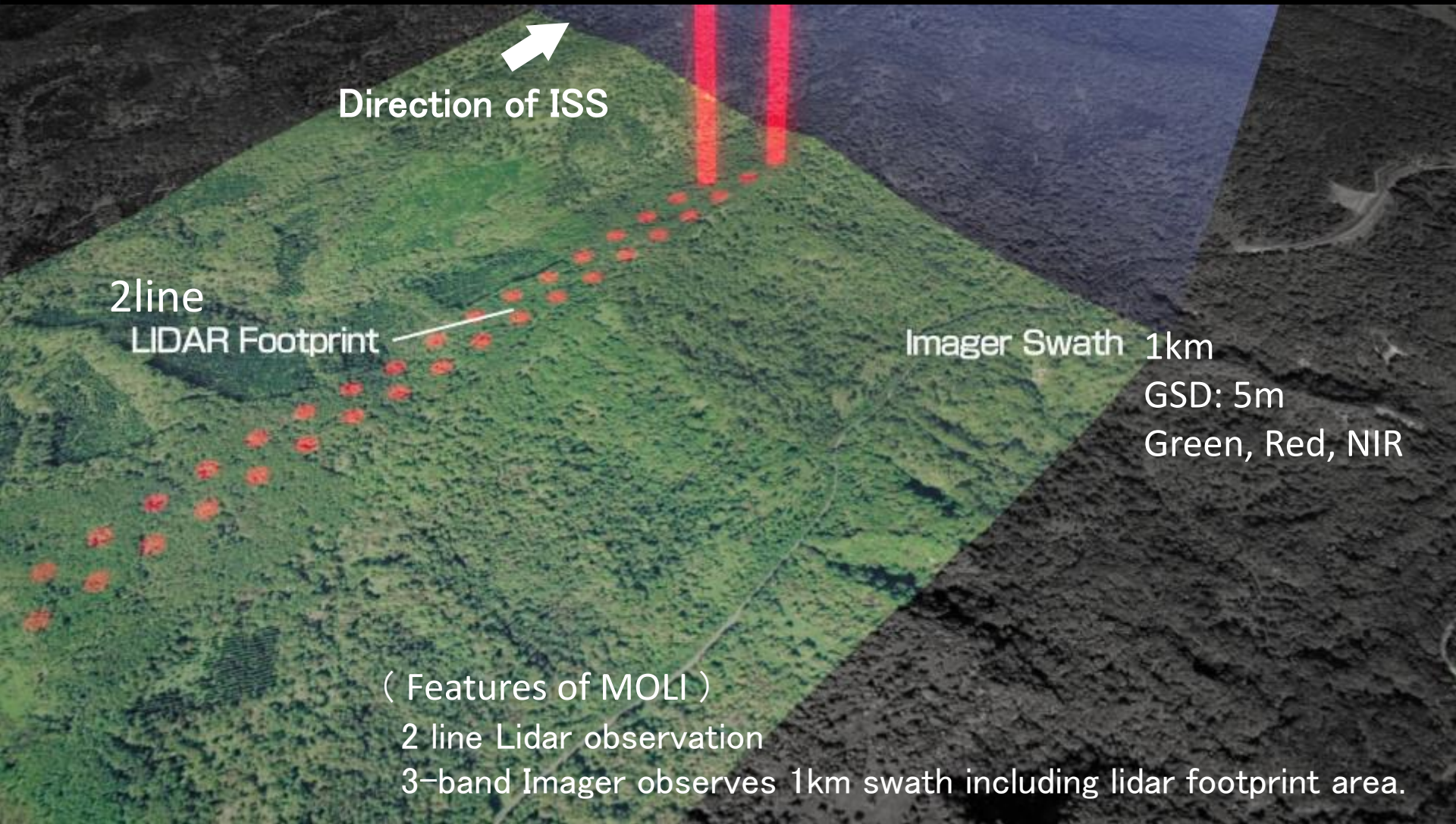


MOLI Observation Image

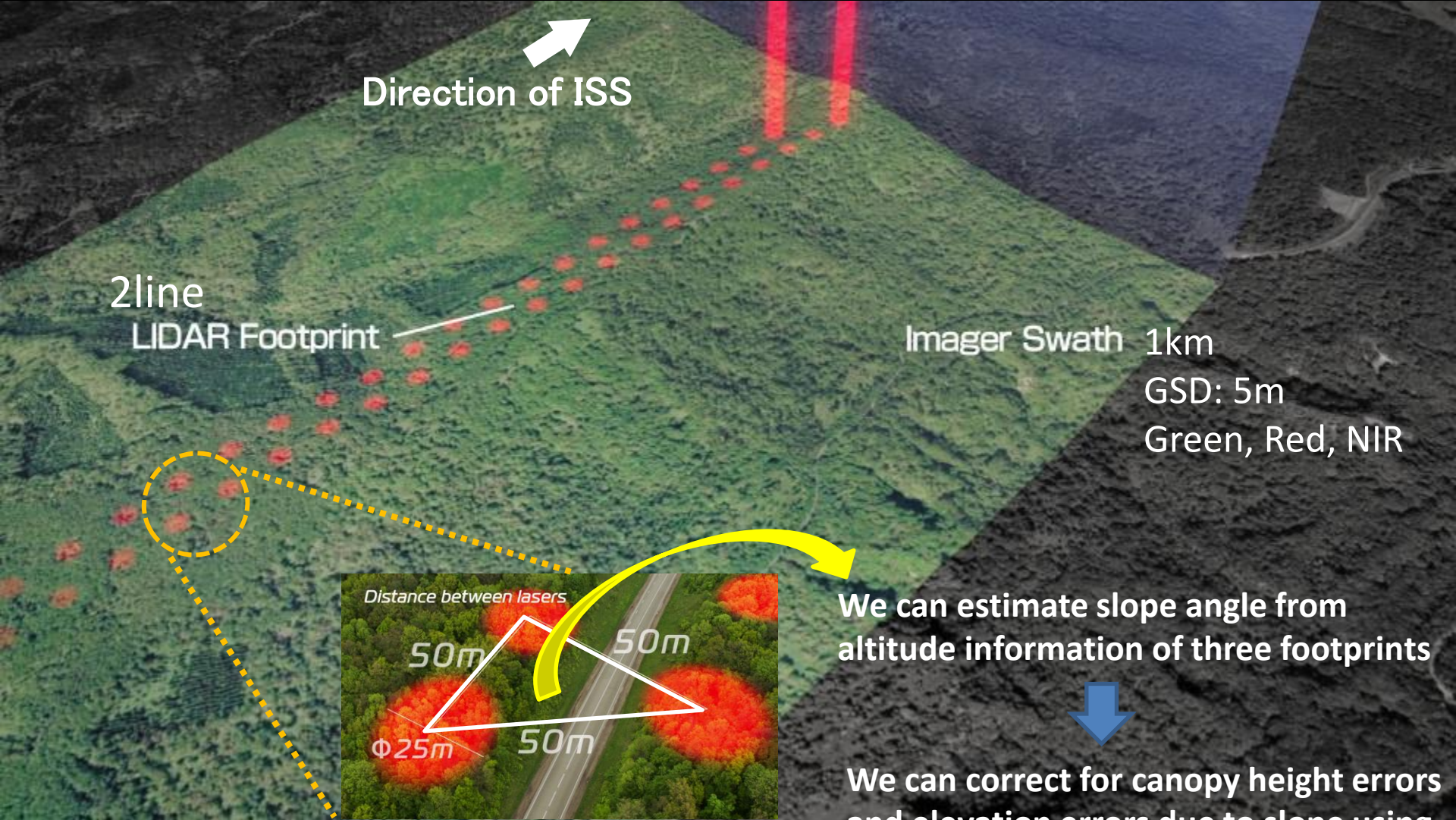


MOLI Observation Image

5/9



MOLI Observation Image



Direction of ISS

2line
LIDAR Footprint

Imager Swath 1km
GSD: 5m
Green, Red, NIR

We can estimate slope angle from altitude information of three footprints

We can correct for canopy height errors and elevation errors due to slope using the slope angle information.

MOLI Imager:

Spatial Resolution: 5m

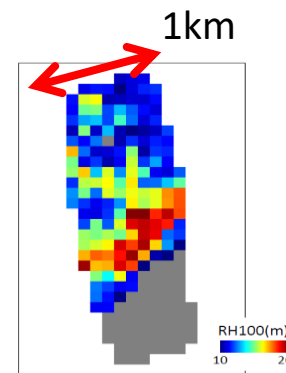
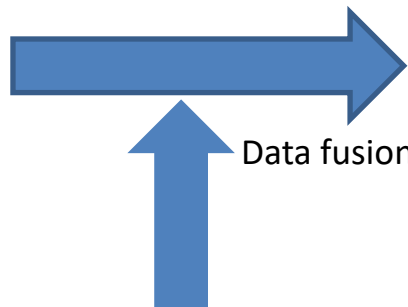
Swath: 1km

Band

Green: 520-600 nm

Red: 610-690 nm

NIR: 760-890 nm

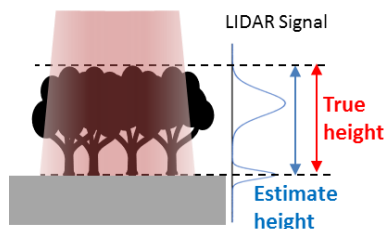


MOLI L3 product

40m resolution

Imager data

+



MOLI Lidar data
(Canopy height)

Data fusion



Canopy height map

Other imagers:

(e.g., Landsat-8)

Spatial Resolution: 30m

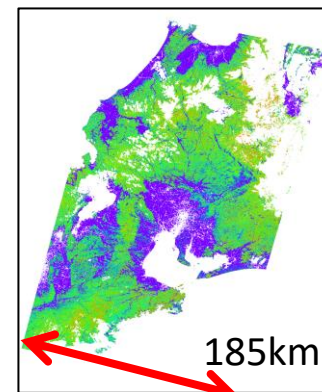
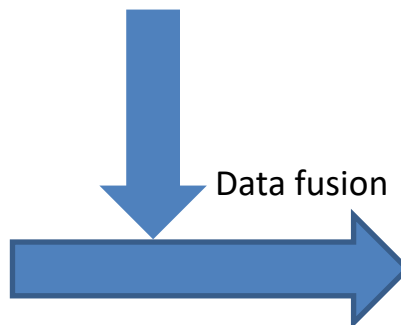
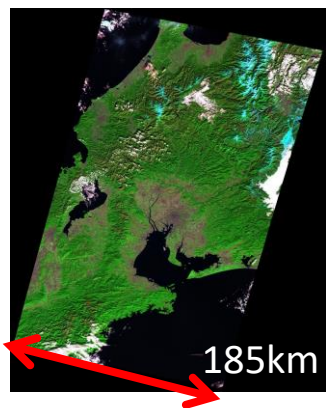
Swath: 185km

Band

BLUE: 450-515 nm

Green: 525-600 nm

Red: 630-680 nm



MOLI L4 product

about 100m resolution

Trial product

Product level	Product category	Products	Remark
L1B (Standard)	Lidar footprint products	Waveforms(≥ 500 Msp/s)	including geolocation data Footprint Position Accuracy ≤ 15 m
	Imager product (1km swath)	Image (Red, Green, NIR)	geometrically corrected
L2 (Standard)	Lidar footprint products	Canopy heights	± 3 m(Canopy Height is under 15m) $\pm 20\%$ (Canopy Height is over 15m)
		Forest biomass	± 25 t/ha (Biomass density is under 100t/ha) $\pm 25\%$ (Biomass density is over 100t/ha)
L3 (Research)	Integrated products with Lidar and imager (1km swath)	Canopy heights	Target
		Forest biomass	○Canopy heights $\pm \sim 5$ m(Canopy Height is under 15m) $\pm \sim 40\%$ (Canopy Height is over 15m)
L4 (Research)	Wall-to-Wall map products (Integrated with GCOM-C/SGLI, SAR Data)	Canopy height map	○Forest biomass $\pm \sim 40$ t/ha (Biomass density is under 100t/ha)
		Forest biomass map	$\pm \sim 40\%$ (Biomass density is over 100t/ha)

✘ Multi-footprint is expected to compensate each product up to 30 degrees of slope.

- 1. JAXA has conducted MOLI study and MOLI will be installed to ISS.**
- 2. MOLI will be able to provide high precision canopy height and forest biomass data, globally.**
- 3. We will also provide canopy height map and forest biomass map created by lidar data and imager data (e.g., SGLI, ALOS-2, 4, ALOS-3) fusion.**
- 4. Target launch is now JFY2024 and we are struggling to get national budget.**