# Study on possibility of Vegetation biomass analysis using Meteorological Satellite

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# Contents

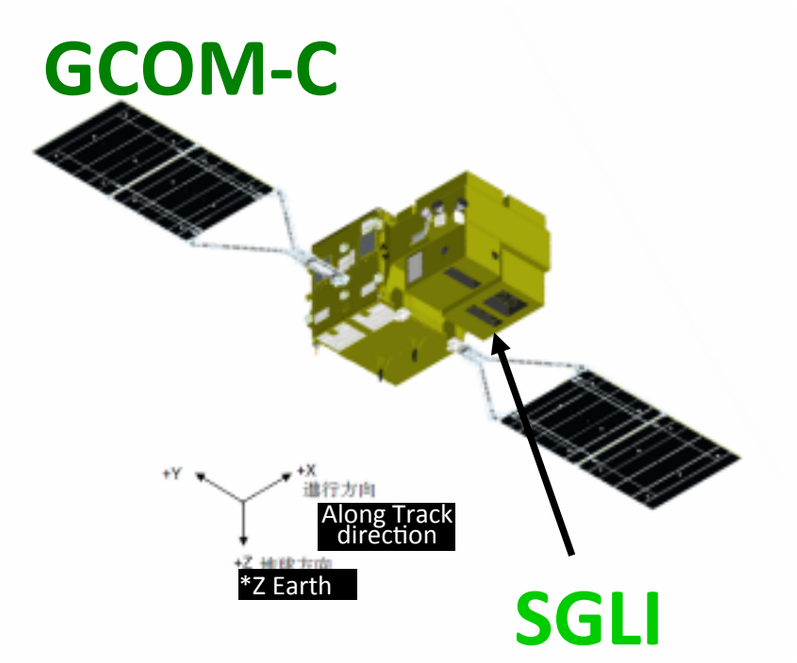
Japan Aerospace Exploration Agency (JAXA) has made a new plan of Global Change Observation Mission (GCOM) for monitoring of global environmental change.

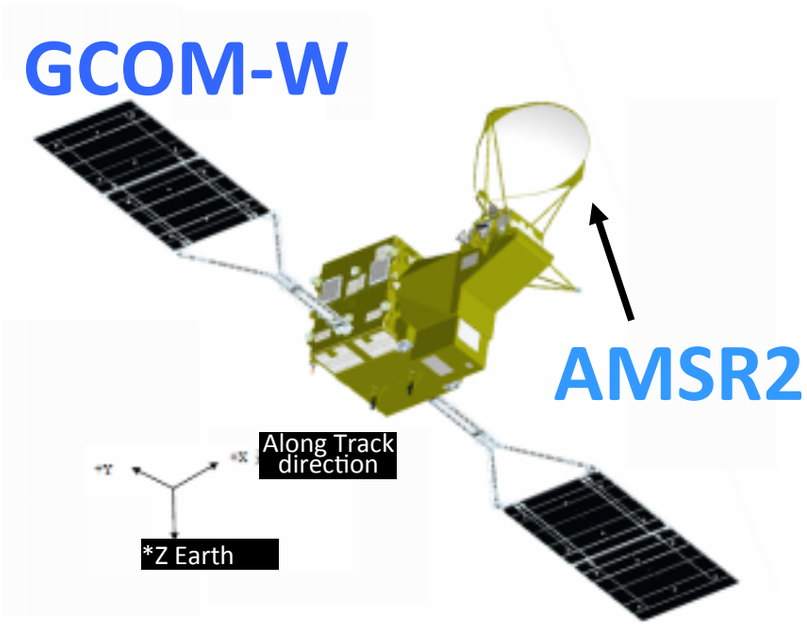
**GCOM**

is follow-on satellite observation mission of ADEOS-II.

will consist of two series of medium-sized satellites:

**GCOM-C (Climate)** and **GCOM-W (Water)**.



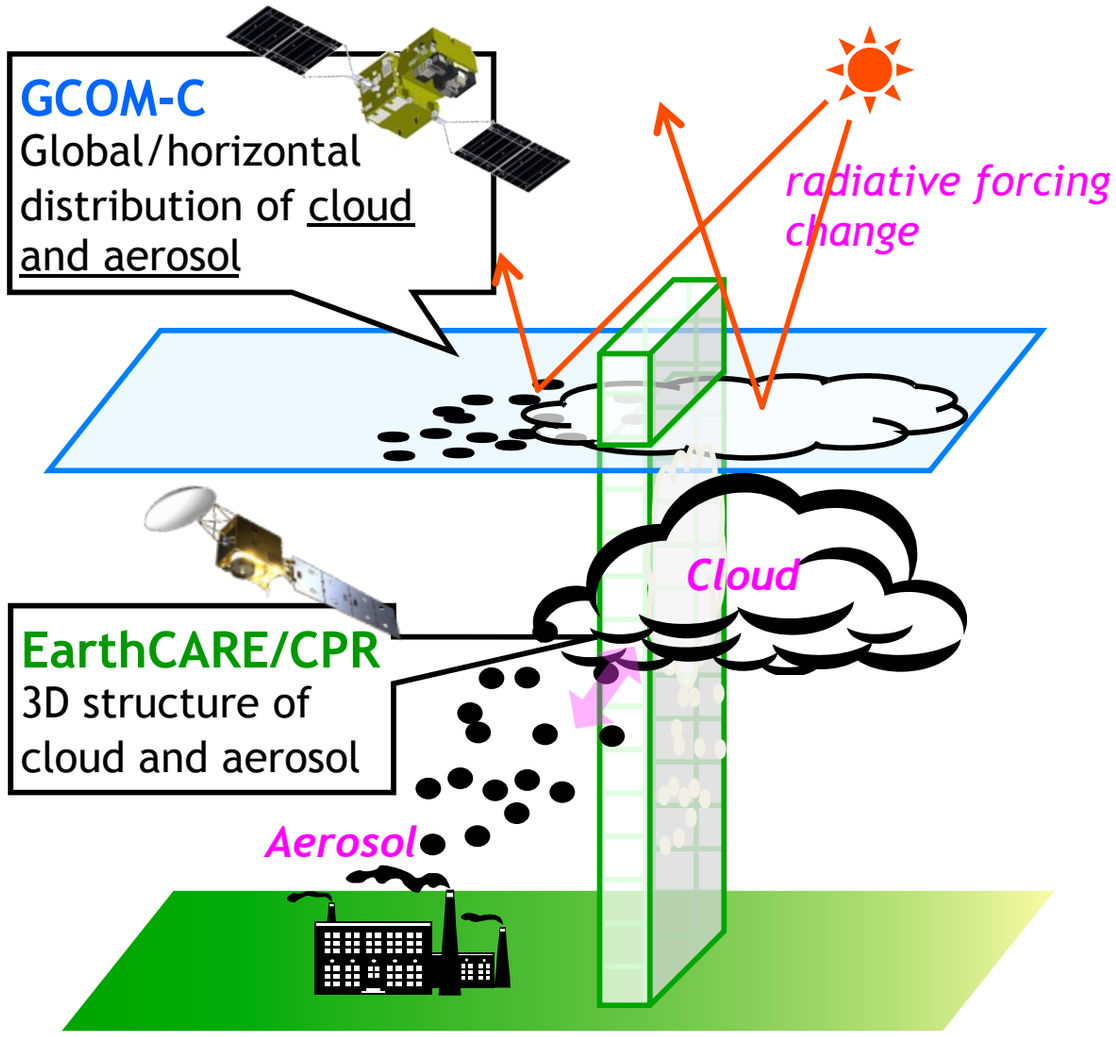




GCOM-C satellite will carry the instrument of SGLI (Second generation GLobal Imager).

GCOM-W satellite l carry the instrument of AMSR2 (Advanced Microwave Scanning Radiometer).

# 1. GCOM-C Science targets

## *Radiative forcing*




Today's the most significant factor: atmospheric $CO_2$

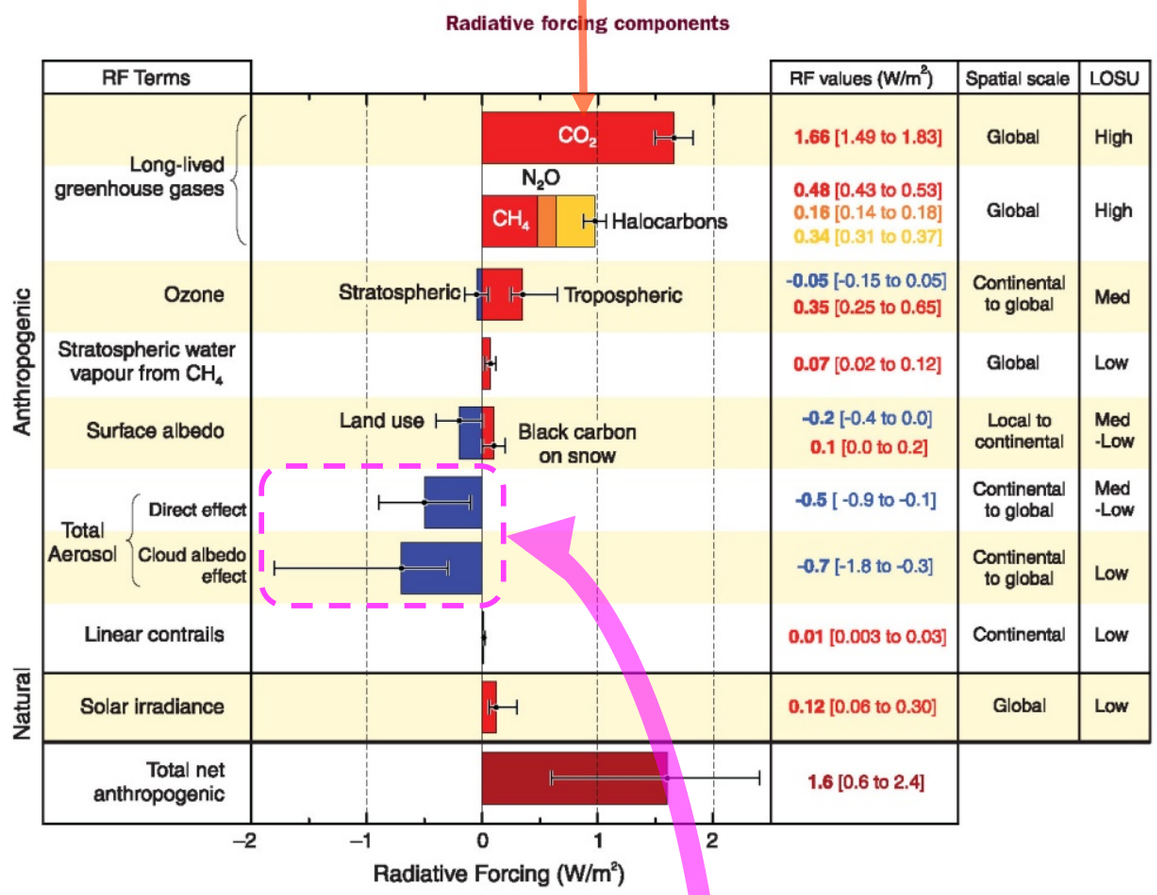



*Figure 2.4. Global average radiative forcing (RF) in 2005 (best estimates and 5 to 95% uncertainty ranges) with respect to 1750 for $CO_2$, $CH_4$, $N_2O$ and other important agents and mechanisms, together with the typical geographical extent (spatial scale) of the forcing and the assessed level of scientific understanding (LOSU). Aerosols from explosive volcanic eruptions contribute an additional episodic cooling term for a few years following an eruption. The range for linear contrails does not include other possible effects of aviation on cloudiness. {WGI Figure SPM.2}*

Monitoring and process investigation about **cloud and aerosol by GCOM-C & EarthCARE**

*Improvement*

Evaluation of model outputs and process parameterization

**Climate model prediction**
present and future cloud and aerosol roles in the global warming scenarios

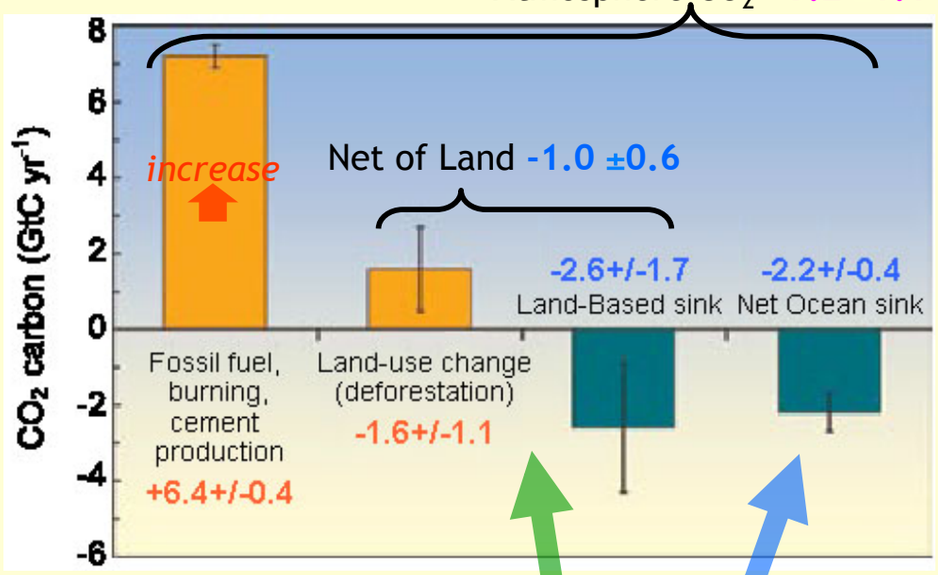
Today's the most significant uncertainty of radiative forcing is direct/indirect role of cloud-aerosol system

# 1. GCOM-C Science targets

## *Carbon cycle in the Land and Ocean*

*Today's the most significant factor*

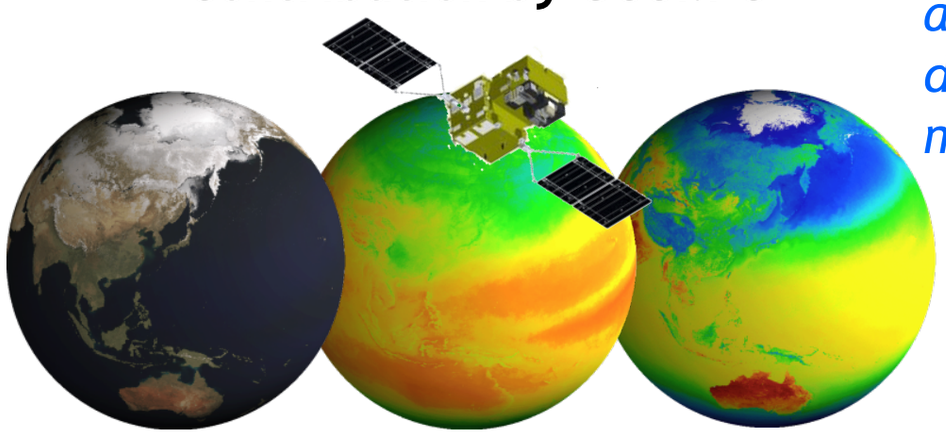
### Today's Carbon budget




Modified from the 4th IPCC report FAQ7.1

*Monitoring of primary production*

**Contribution by GCOM-C**



*Process study and long-term diagnosis with model researches*

### Future Carbon cycle

$CO_2$ increase and Global warming

**Global environmental change**
(irradiance, temperature, $CO_2$, precipitation)

*Several tens of % uncertainty in the global warming prediction*

*Future ecosystem $CO_2$ sink and pool*

**Land**
- Photosynthesis production
  - Vegetation index
  - Leaf area index
  - Primary production
  - Above-ground biomass
- Land cover/use
- Soil respiration

**Ocean**
- Photosynthesis production
  - Phytoplankton chl-a
  - Sea surface temperature
  - PAR
  - Dissolved organic matter
- $CO_2$ solution, pH
- Sedimentation

Feedback

*Change of atmosphere $CO_2$*

# 1. GCOM-C Science targets

## *Contribution to the model research and operational use*

- *Continuous (>10yr) and consistent observation and products*
- *Connection between model parameters and satellite observations*

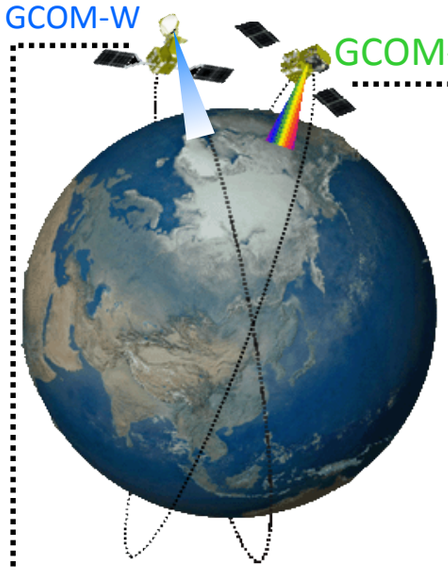
*Satellite/sensor and algorithm development*

*Cooperation with the climate model research institutions*

### GCOM observation

GCOM-W

GCOM-C



Frequent and long-term (>10yer) global observation system required for earth environment change monitoring and prediction

### GCOM observation

**Radiation budget**
- Surface albedo
- Snow ice
- Cloud/ aerosol
- SST/ LST

**Carbon cycle**
- Vegetation cover
- Primary production
- Coastal environment

**Water cycle**
- Water vapor, cloud, precipitation
- Soil moisture
- Sea ice, snow
- SST, wind

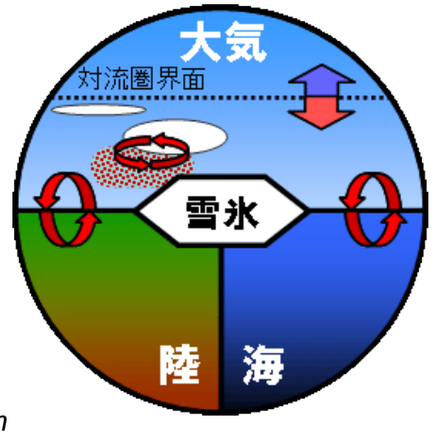
Input

Comparison

*Products or radiance with radiative transfer*

### Model prediction

Climate system model



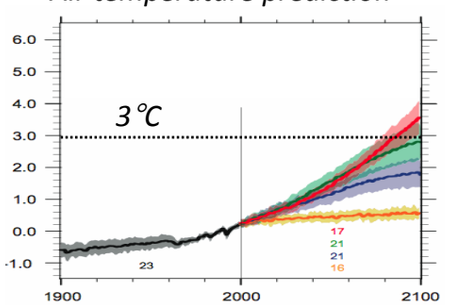

- Improvement of parameterization about radiation budget and carbon cycle, etc. in climate prediction model.
- Verification and improvement of prediction of the earth environment change including the water cycle by comparison with the satellite observation.

Improve accuracy

### Prediction results

- Surface temperature
- Sea level
- Snow and sea ice area
- Environmental change
- Rain/drought distribution
- Extreme weather frequency
- Land cover

*Air temperature prediction*




Data application

Operational use for fishery, sea route, weather forecast, and climate monitoring

Knowledge

Understanding of the climate system and the global warming

Future prediction

Policy design through prediction improvement

# ◆ 3. GCOM-C1/SGLI products

**Common**

**Land**
**14** products

**Atmosphere**
**10** products

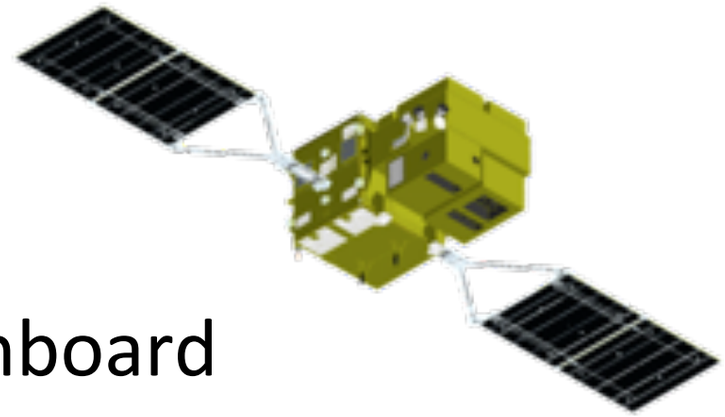
**Ocean**
**14** products

**Cryosphere**
**12** products

| Area | Group | Product | Category | Production unit | Grid size |
|---|---|---|---|---|---|
| Comm | Radiance | TOA radiance (including system geometric correction) | Standard | Scene | VNR,SWI Land/coast: 250m, offshore: 1km, polarimetory:1km TIR Land/coast: 500m, offshore: 1km |
| Land | Surface reflectance | Precise geometric correction | Standard | Scene, Global (mosaic 1, 16 days, month) | 250m |
| | | Atmospheric corrected reflectance (incl. cloud detection) | | Scene, Global (1, 16 days, month) | |
| | Vegetation and carbon cycle | Vegetation index | | | |
| | | fAPAR | | | 1km |
| | | Leaf area index | | | |
| | | Above-ground biomass | | | 250m, 1km |
| | | Vegetation roughness index | | | 500m |
| | | Shadow index | | | |
| | Temperature | Surface temperature | | | |
| | Application | Land net primary production | Research | Global (month, year) | 1km |
| | | Water stress trend | | Scene, Global (1, 16 days, month) | 500m |
| | | Fire detection index | | Scene | |
| | | Land cover type | | Global (month, season) | 250m |
| | | Land surface albedo | | Scene, Global (1, 16 days, month) | 1km |
| Atmosphere | Cloud | Cloud flag/Classification | Standard | Scene, Global〈1 day, month〉 | 1km |
| | | Classified cloud fraction | | Global〈1 day, month〉 | 1km (scene), 0.1deg (global) |
| | | Cloud top temp/height | | Scene, Global〈1 day, month〉 | |
| | | Water cloud OT/effective radius | | | |
| | | Ice cloud optical thickness | | | |
| | | Water cloud geometrical thickness | Research | | |
| | Aerosol | Aerosol over the ocean | Standard | | |
| | | Land aerosol by near UV | | | |
| | | Aerosol by Polarization | | | |
| | Radiation budget | Long-wave radiation flux | Research | | |
| Ocean | Ocean color | Normalized water-leaving radiance (incl. cloud detection) | Standard | Scene, Global (1, 8 days, month) | Coast: 250m Offshore: 1km Global: 4-9km |
| | | Atmospheric correction parameter | | | |
| | | Photosynthetically available radiation | | | |
| | | Euphotic zone depth | Research | | |
| | In-water | Chlorophyll-a concentration | Standard | | |
| | | Suspended solid concentration | | | |
| | | Colored dissolved organic matter | | | |
| | | Inherent optical properties | Research | | |
| | Temperature | Sea-surface temperature | Standard | | Coast: 500m Others: Same as above |
| | Application | Ocean net primary productivity | Research | | |
| | | Phytoplankton functional type | | | Coast: 250m Others: Same as above |
| | | Red tide | | | |
| | | multi sensor merged ocean color | | | Coast: 250m Offshore: 1km |
| | | multi sensor merged SST | | | |
| Cryosphere | Area/ distribution | Snow and Ice covered area (incl. cloud detection) | Standard | Scene, Global (1, 16 days, month) | 250m (scene), 1km (global) |
| | | Okhotsk sea-ice distribution | | Area (1day) | 250m |
| | | Snow and ice classification | Research | Global (16 days, month) | 1km |
| | | Snow covered area in forests and mountains | | Area (1, 8 days) | 250m |
| | Surface properties | Snow and ice surface Temperature | Standard | Scene, Global (1, 16 days, month) | 500m (scene), 1km (global) |
| | | Snow grain size of shallow layer | | | 250m (scene), 1km (global) |
| | | Snow grain size of subsurface layer | Research | | 1km |
| | | Snow grain size of top layer | | | 250m (scene), 1km (global) |
| | | Snow and ice albedo | | Global (1, 16 days, month) | 1km |
| | Surface properties | Snow impurity | | Scene, Global (1, 16 days, month) | 250m (scene), 1km (global) |
| | | Ice sheet surface roughness | | Area (Season) | 1km |
| | Boundary | Ice sheet boundary monitoring | | | 250m |

# Contents

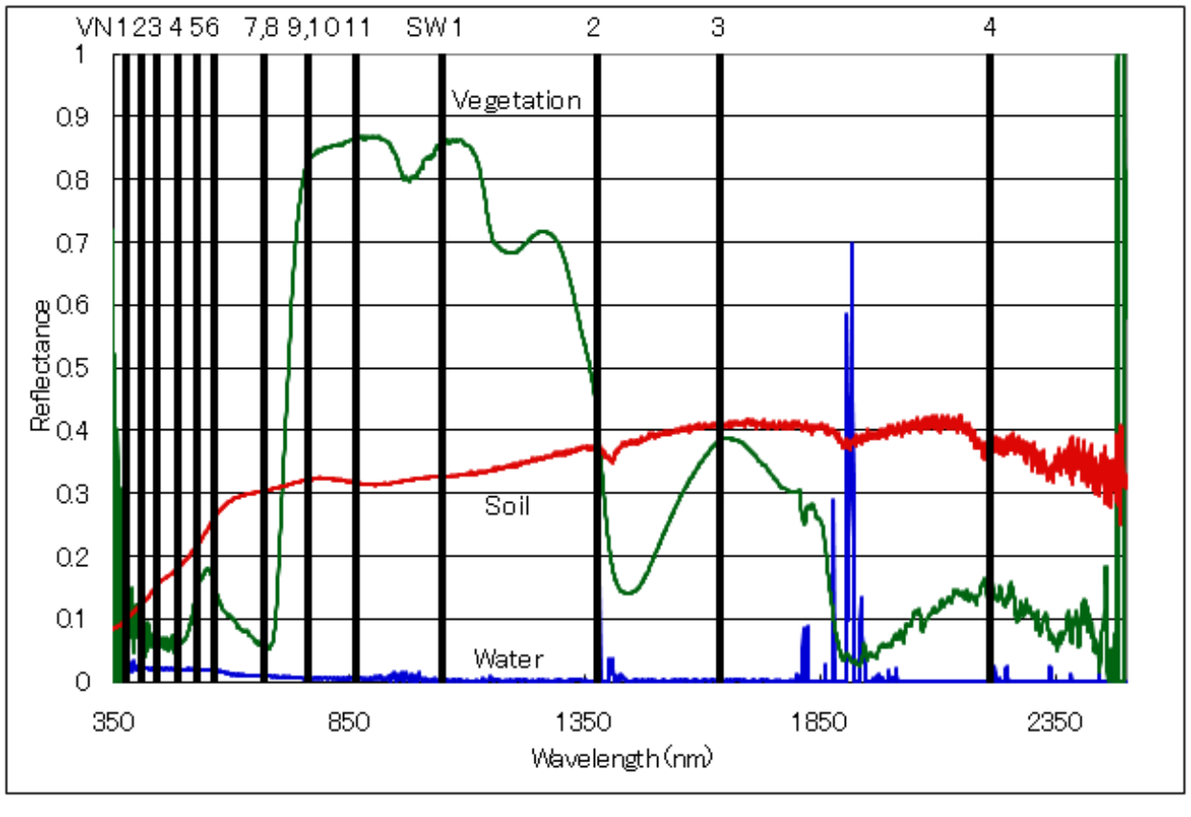
# ◆ 2. Specification of GCOM-C1/SGLI



## GCOM-C1/SGLI

SGLI (Second generation GLobal Imager) is an onboard GCOM-C satellite, and provides GLI follow-on sensors.

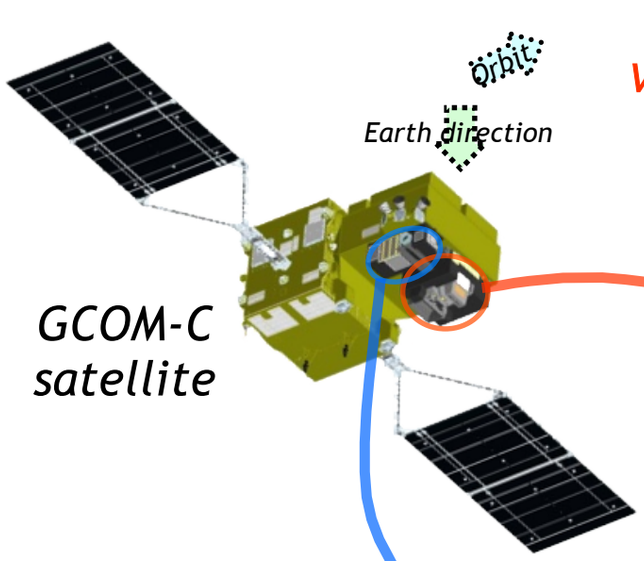
## ◇ SGLI channel specifications




| CH | λ | Δλ | $L_{std}$ | $L_{max}$ | SNR at $L_{std}$ | IFOV |
|---|---|---|---|---|---|---|
| | VN, P, SW: nm<br>T: μm | | VN, P:<br>W/m²/sr/μm<br>T: Kelvin | | VN, P, SW: -<br>T: NEΔT | m |
| VN1 | 380 | 10 | 60 | 210 | 250 | 250 |
| VN2 | 412 | 10 | 75 | 250 | 400 | 250 |
| VN3 | 443 | 10 | 64 | 400 | 300 | 250 |
| VN4 | 490 | 10 | 53 | 120 | 400 | 250 |
| VN5 | 530 | 20 | 41 | 350 | 250 | 250 |
| VN6 | 565 | 20 | 33 | 90 | 400 | 250 |
| VN7 | 670 | 10 | 23 | 62 | 400 | 250 |
| VN8 | 670 | 20 | 25 | 210 | 250 | 250 |
| VN9 | 763 | 8 | 40 | 350 | 400 | 1000 |
| VN10 | 865 | 20 | 8 | 30 | 400 | 250 |
| VN11 | 865 | 20 | 30 | 300 | 200 | 250 |
| P1 | 670 | 20 | 25 | 250 | 250 | 1000 |
| P2 | 865 | 20 | 30 | 300 | 250 | 1000 |
| SW1 | 1050 | 20 | 57 | 248 | 500 | 1000 |
| SW2 | 1380 | 20 | 9 | 103 | 150 | 1000 |
| SW3 | 1630 | 200 | 3 | 50 | 57 | 250 |
| SW4 | 2210 | 50 | 1.9 | 20 | 211(TBD) | 1000 |
| T1 | 10.8 | 0.7 | 300 | 340 | 0.2 | 500(opt. 250) |
| T2 | 12.0 | 0.7 | 300 | 340 | 0.2 | 500(opt. 250) |

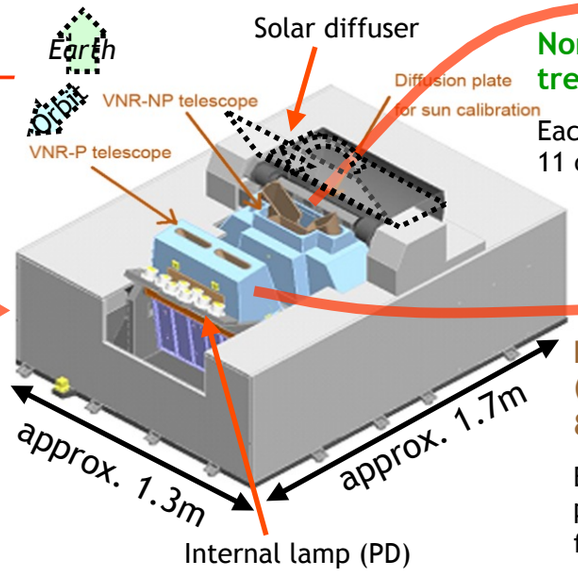
# 2. GCOM-C sensor

## *2.1 Second generation global imager (SGLI)*



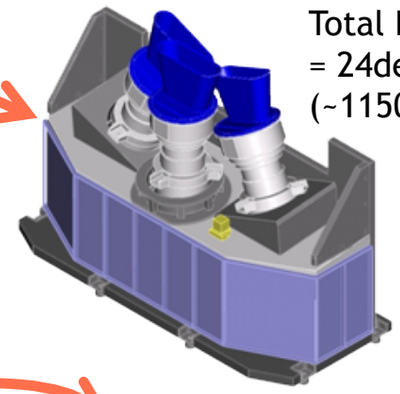

*GCOM-C satellite*

*Visible and Near–infrared Radiometer (SGLI-VNR)*




**Non-polarization tree telescopes**

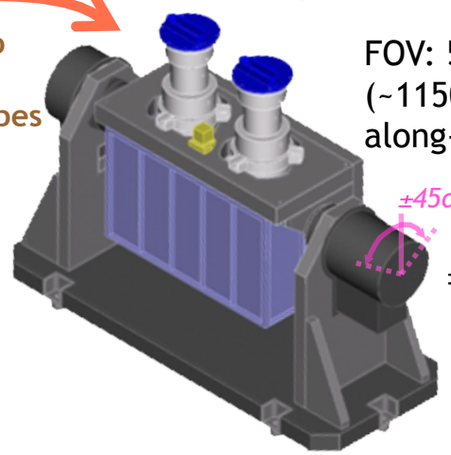
Each has the same 11 channels



Total FOV: 70deg
= 24deg × 3 telescopes
(~1150km@nadir)

**Polarization two (670nm and 865nm) telescopes**

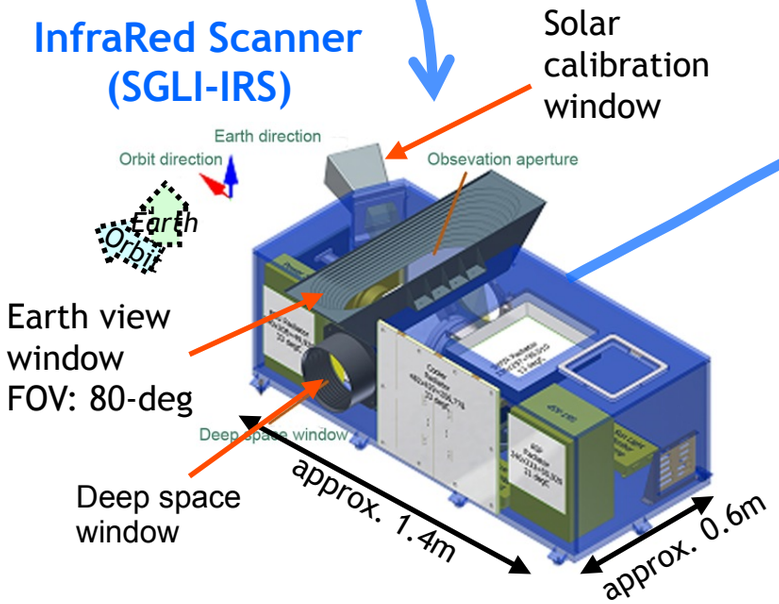
Each has tree polarization-angle filters




FOV: 55deg
(~1150km@±45deg along-track slant)

±45deg along-track slant observation

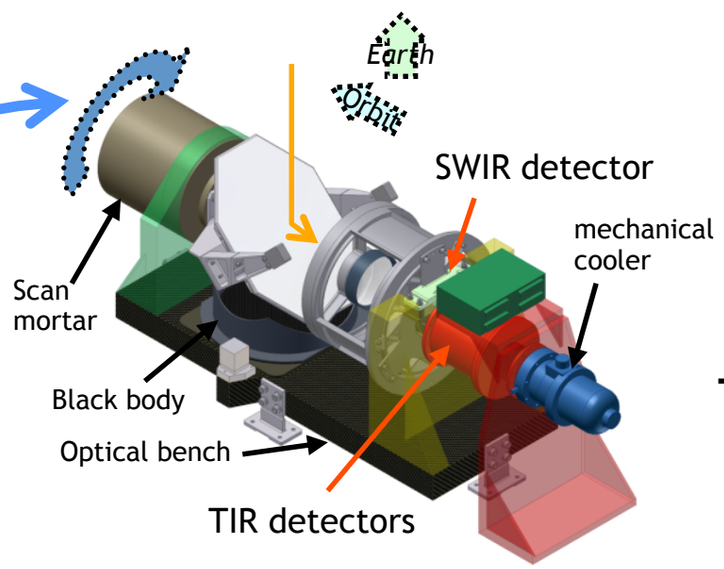
**InfraRed Scanner (SGLI-IRS)**

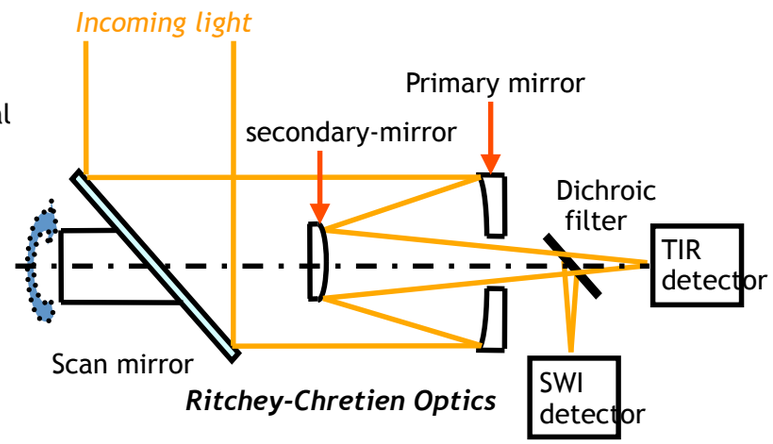



Solar calibration window

Earth view window
FOV: 80-deg

Deep space window



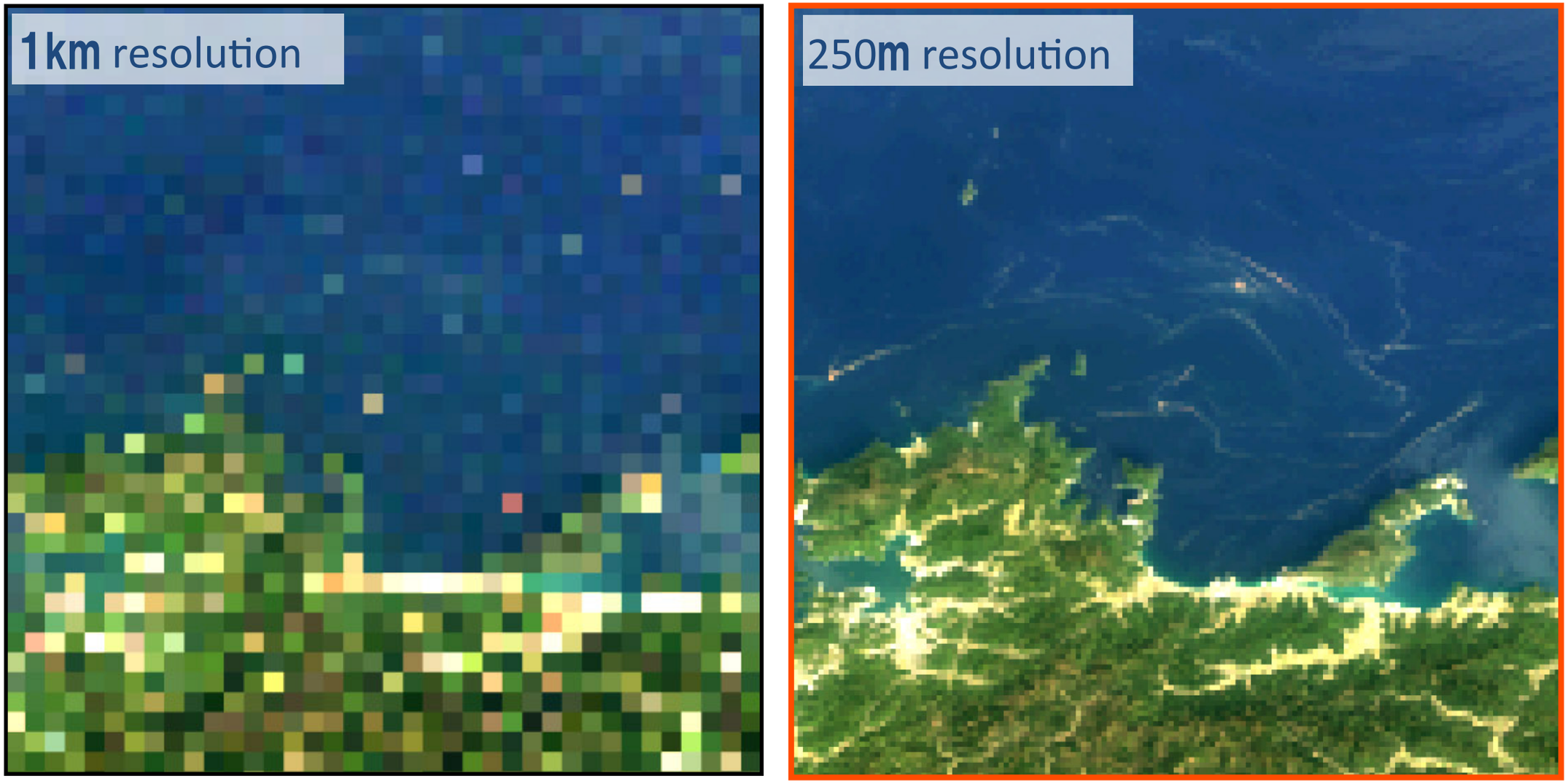




- SGLI initial design and trial manufacturing (breadboard model: BBM) has been done in 2009.
- The BBM includes non-polarized and polarized telescopes, spectral filter assembly, mirror scanning system, detector cooling system, and onboard calibration systems.
- Their results will be reflected to the next engineering model (EM) development.

# 3. GCOM-C Observation Products

*Environmental phenomena captured by 250m resolution*

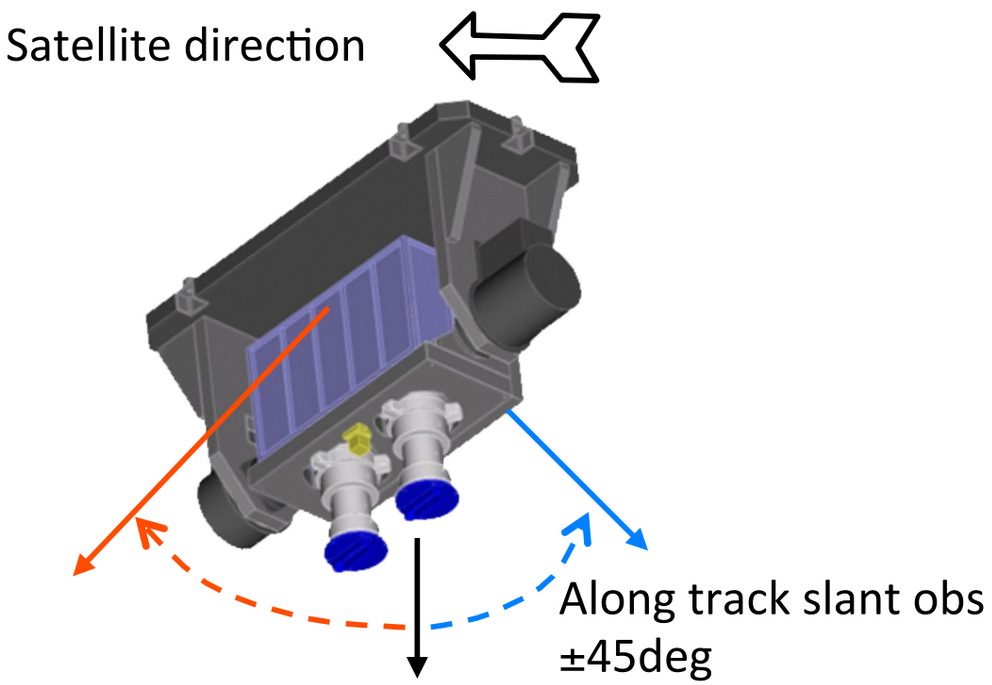
- *SGLI's 250-m visible bands and 1150-km swath enable regular monitoring of the land and coastal environment such as redtide*

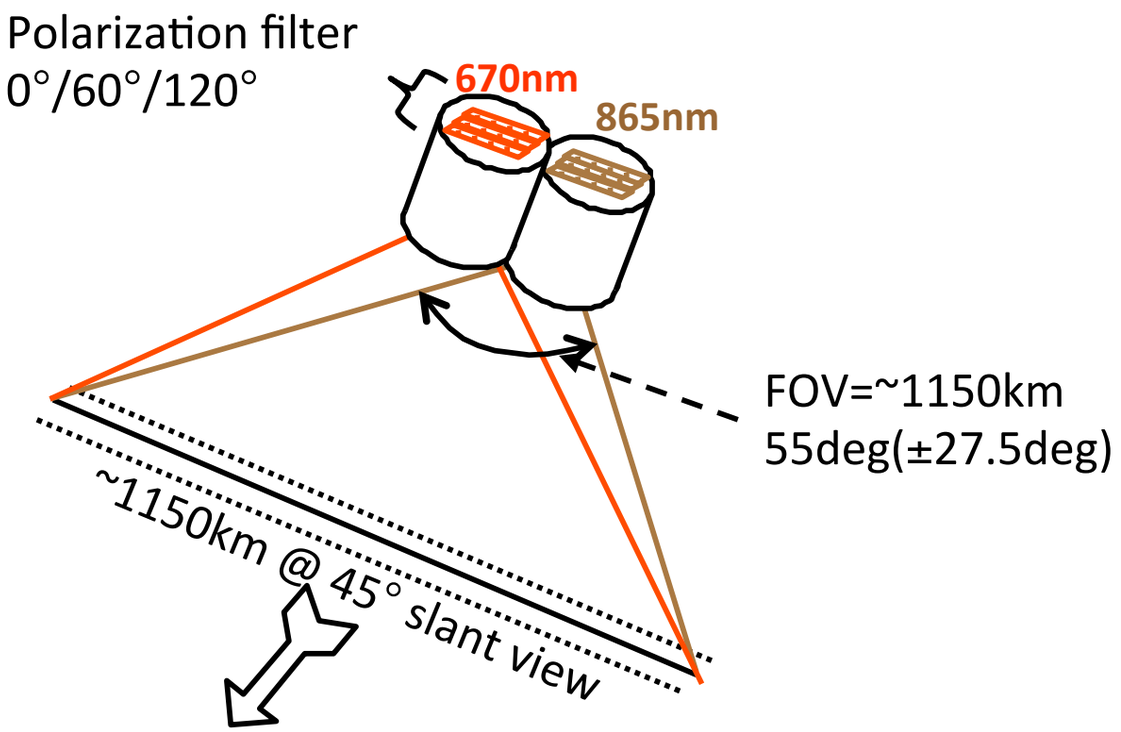


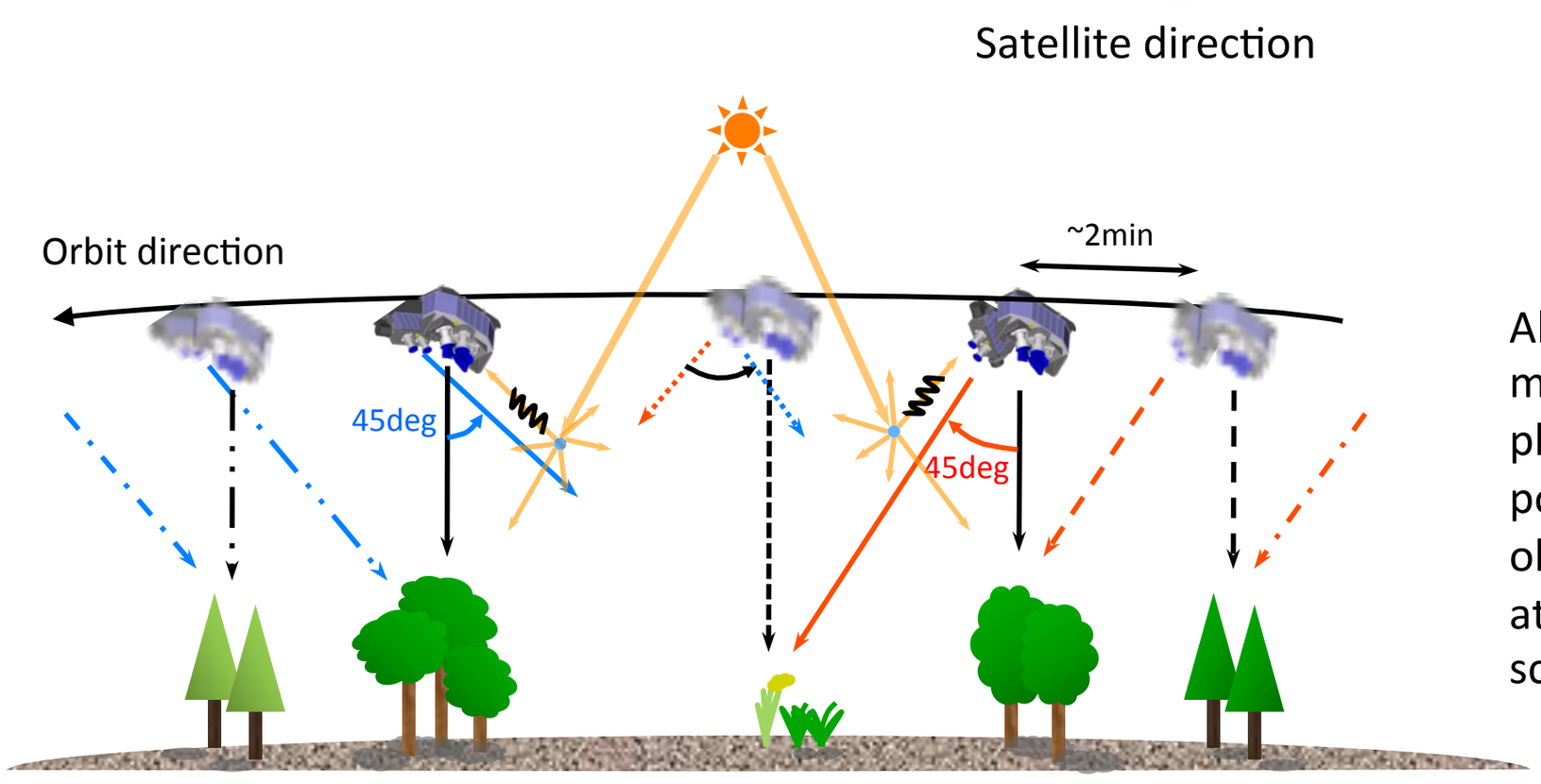

1-km and 250-m resolution RGB image simulated using AVNIR-2.
Light red filaments in the 250m image were the Noctilca redtide on 19 April 2009 in Wakasa-Bay.

# 3. GCOM-C Observation Products

## *SGLI Polarimetry*



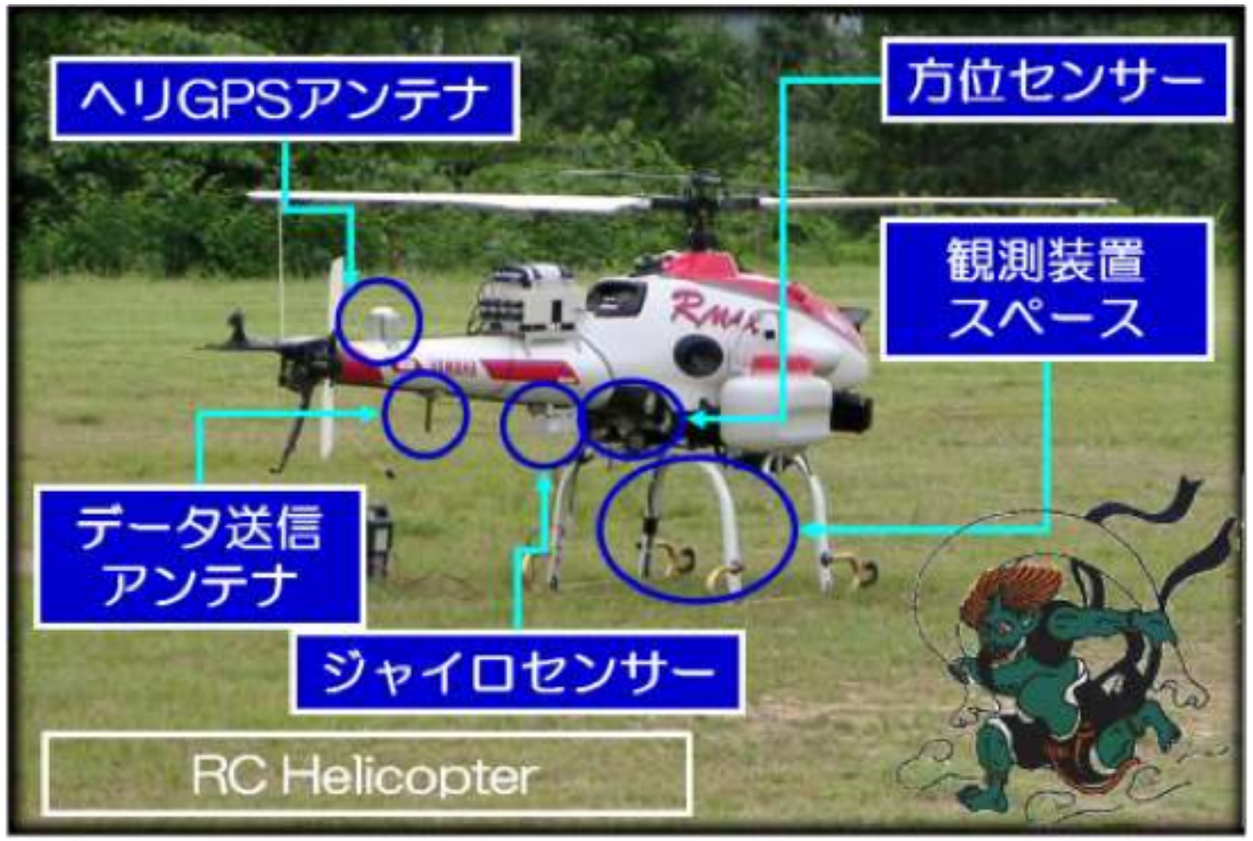




Along-track ±45deg modes will be planned for polarization observation of the atmospheric scattering

# Discussion points

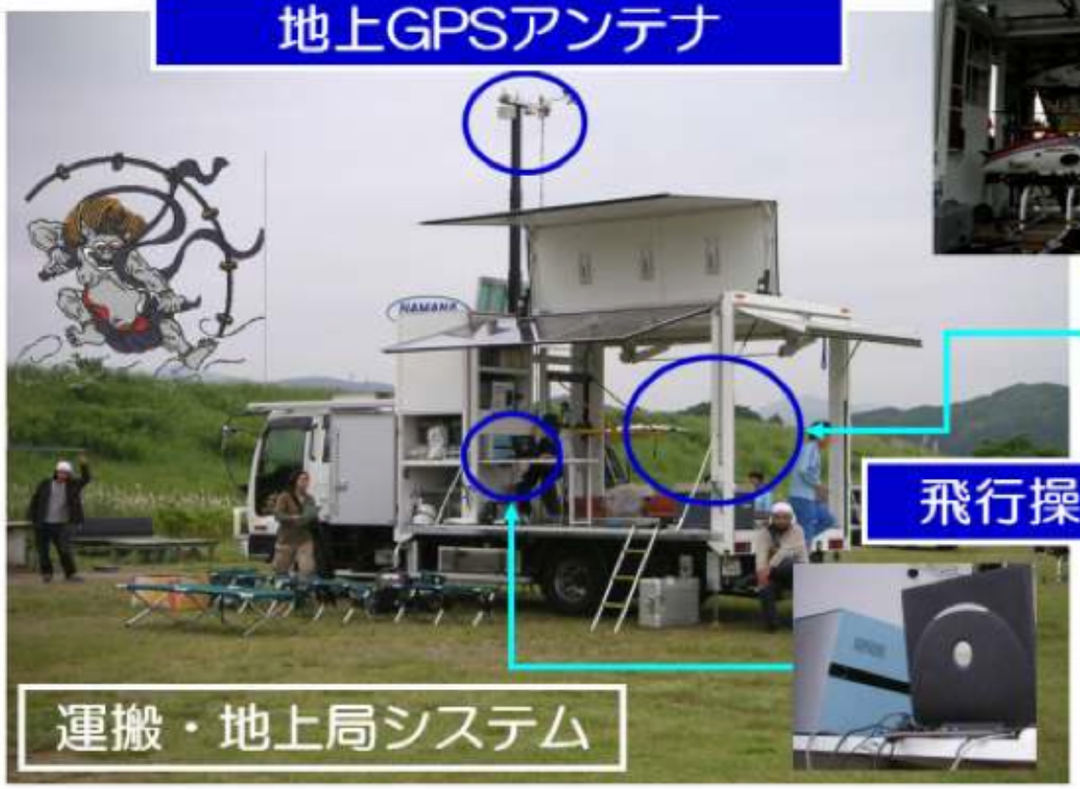
- It is necessary to develop validation method for BRDF
- How to get AGB ( Biomass ). It is important product for Carbon budget understanding

# Contents




CODE : Fujin (Flying Unit for Global INvestigation)

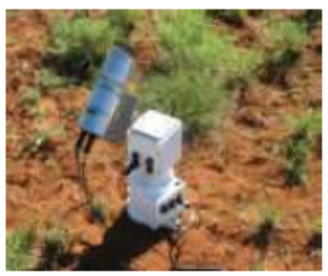
| | Item | RMAX Type II |
|---|---|---|
| Performance | Utility Payload | 10~15kg (Maximum 31kg) |
| | Flight Duration | 50 minutes(6 litter) |
| | Maximum Takeoff Weight | 95kg |
| | Control Range | 1.5km |
| | Control System | YACS |
| Body | Overall Length | 3,630mm (rotors included) |
| | Overall Width | 1,640mm |
| | Overall Height | 1,220mm |
| Engine | Displacement | 246cc(Water-cooled, 2-stroke, horizontally opposed 2-cylinder) |
| | MaximumOutput /Maximum Torque | 21PSÅ^2.6kgm |
| | Starting System | Cell Motor |
| | Fuel | Regular gasoline mixed with 2-stroke engine oil |




ヘリ格納庫
（3台格納可）


飛行操作PC

Fish-eye sky view camera

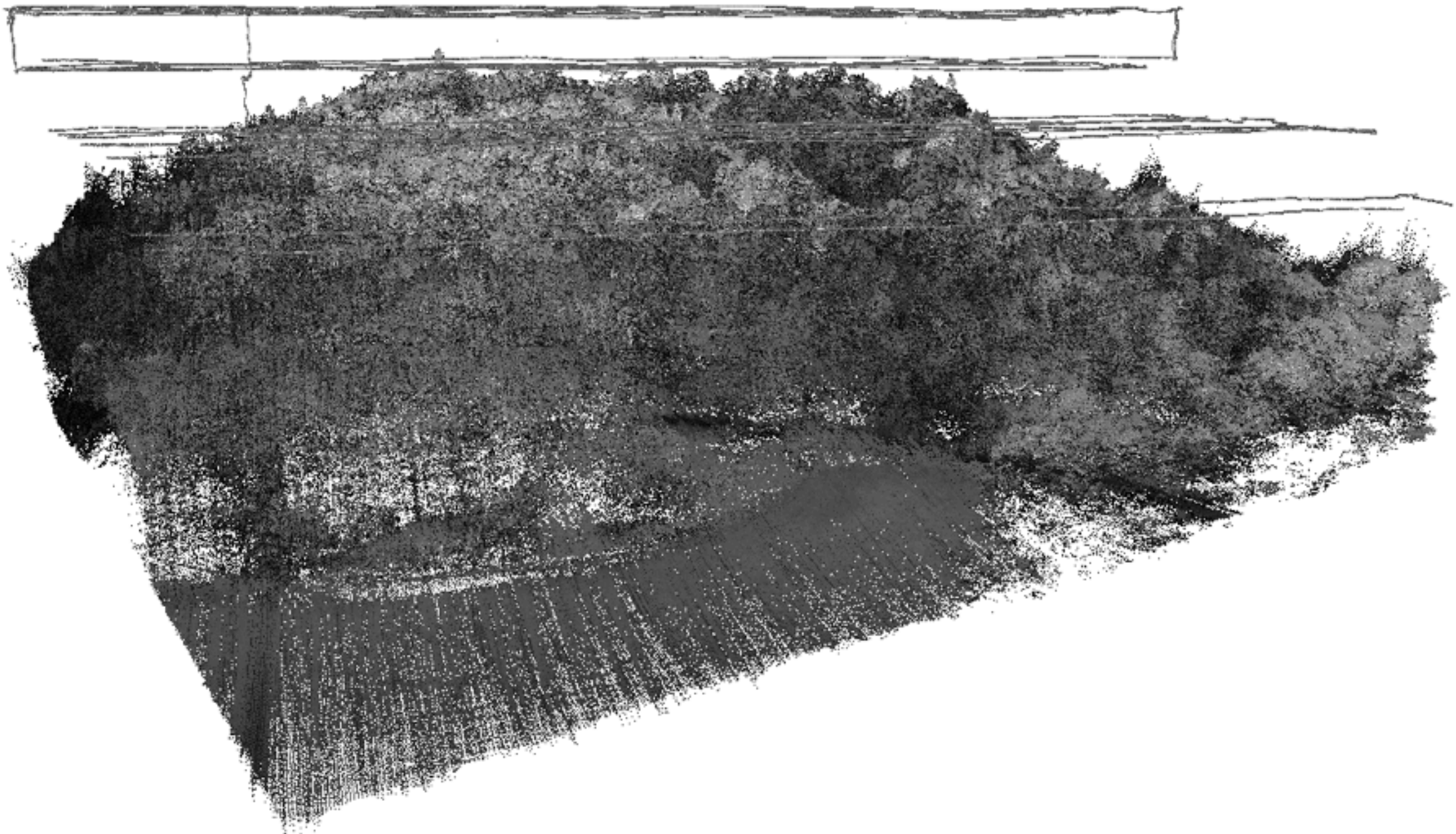


Sun photo meter

Equipment which is mounted on the UAV

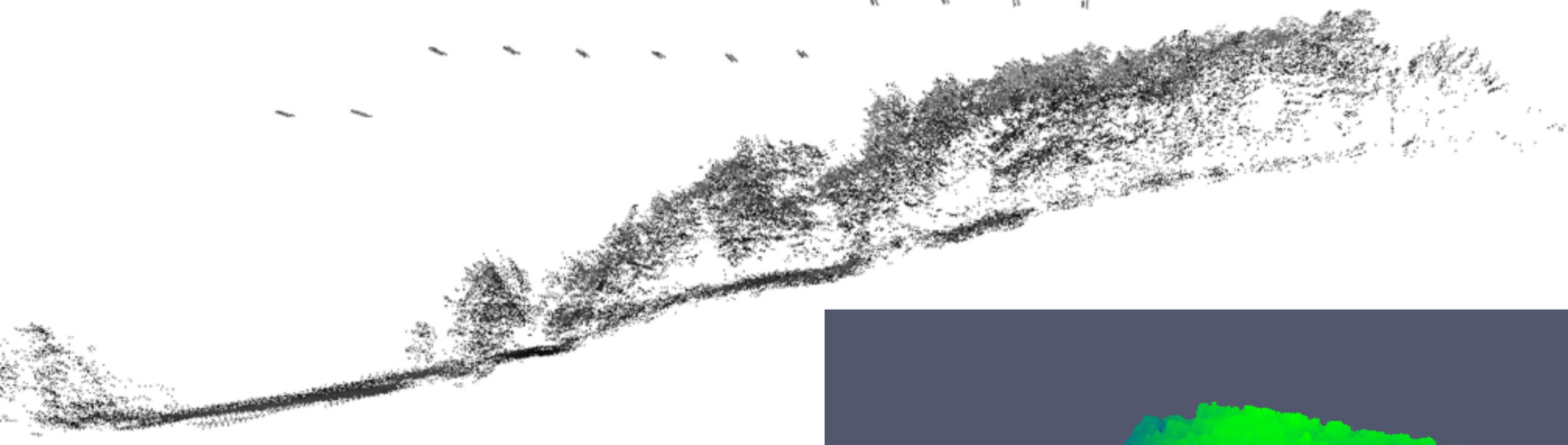
- Spectrometer
- Laser scanner
- Digital camera
- Video
- Hyperspectral camera
- Thermal infrared image

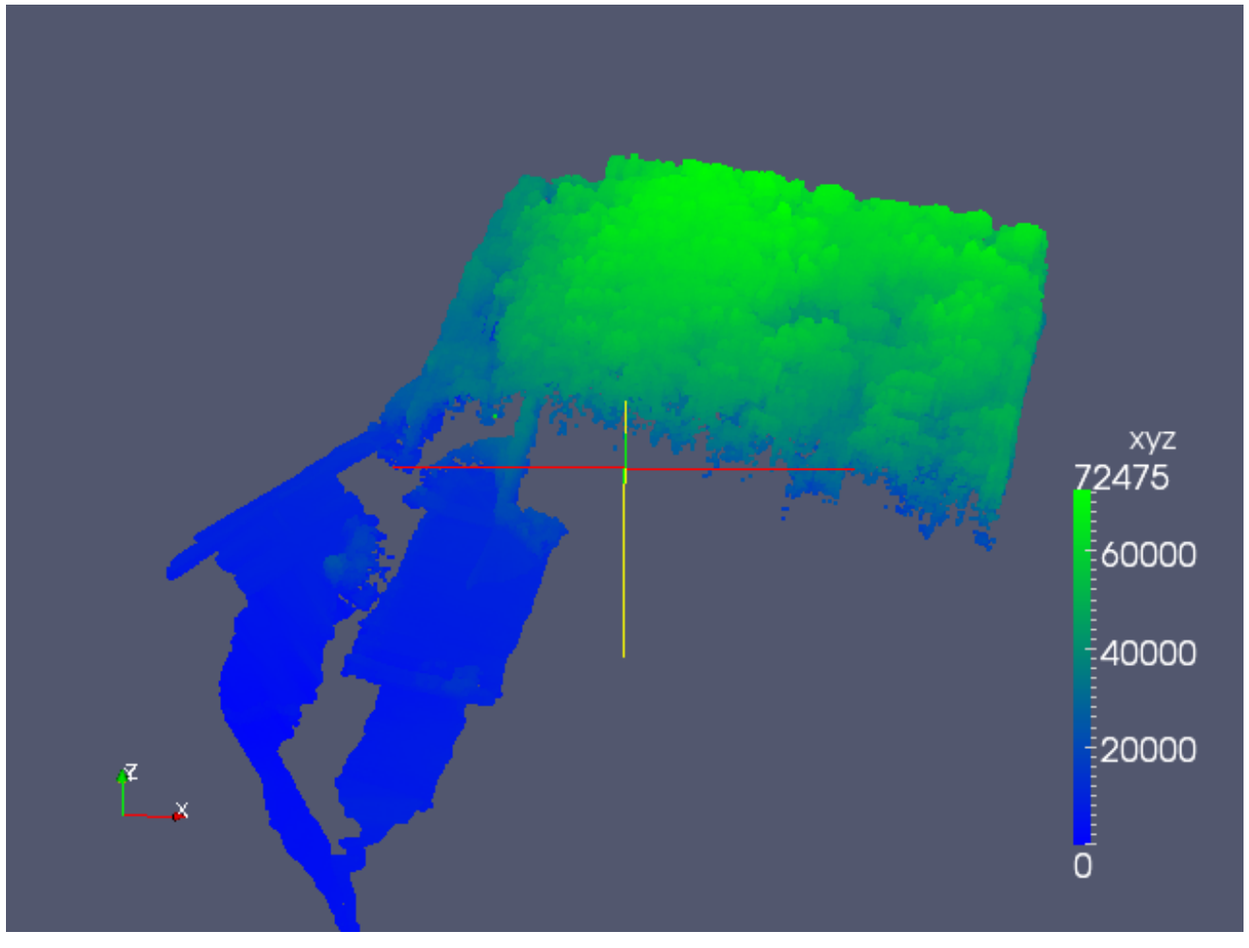
# Laser scanner



F1F2marge.3d

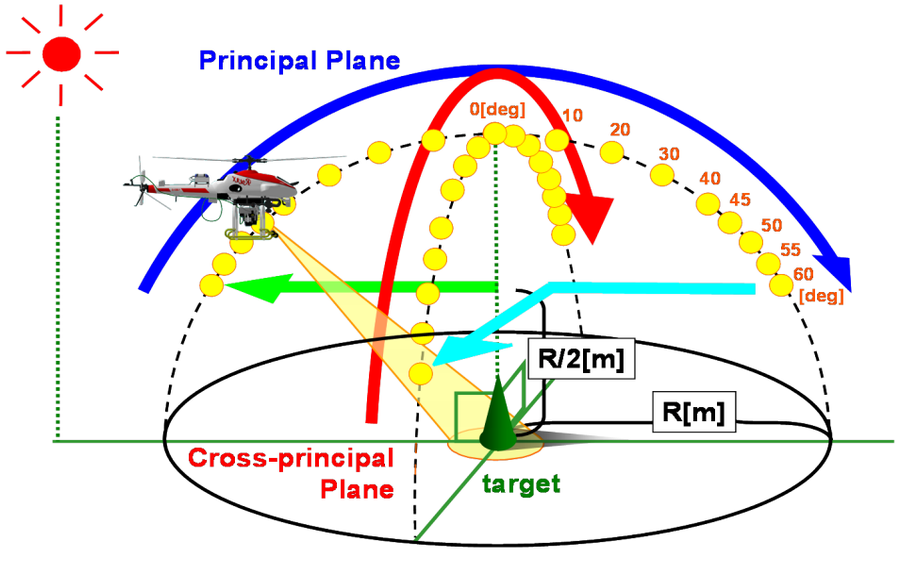
# Laser scanner



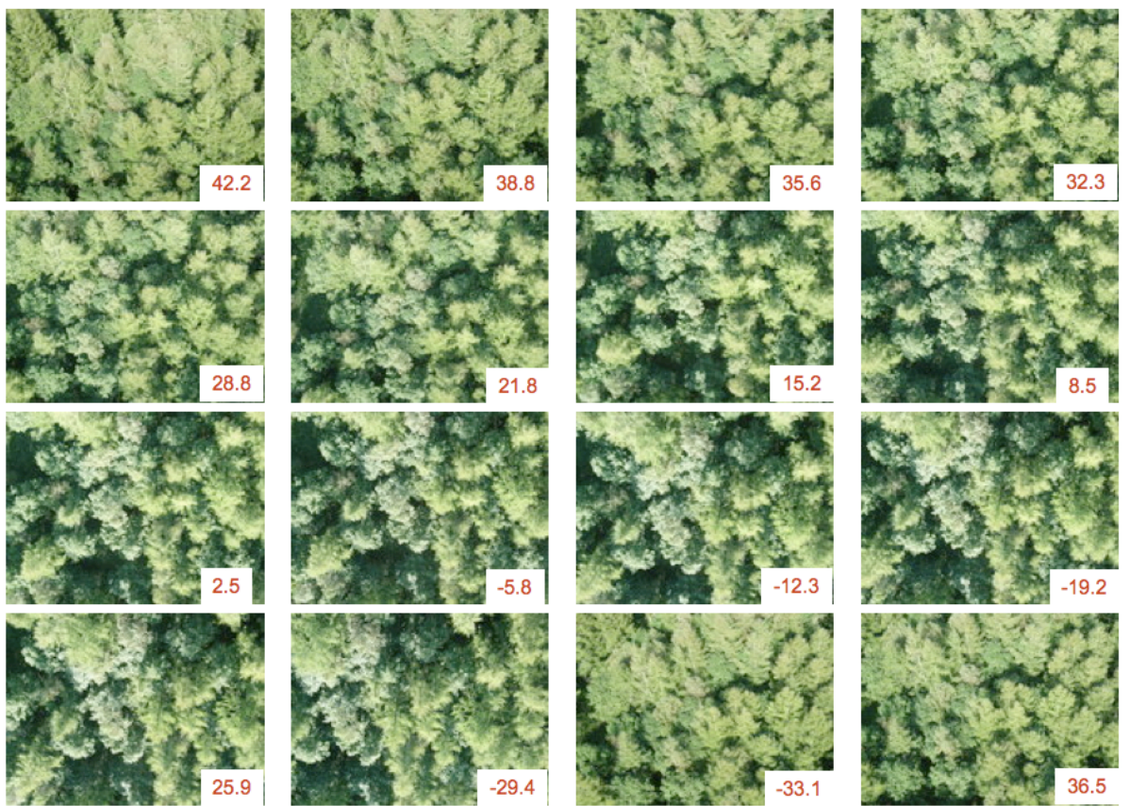


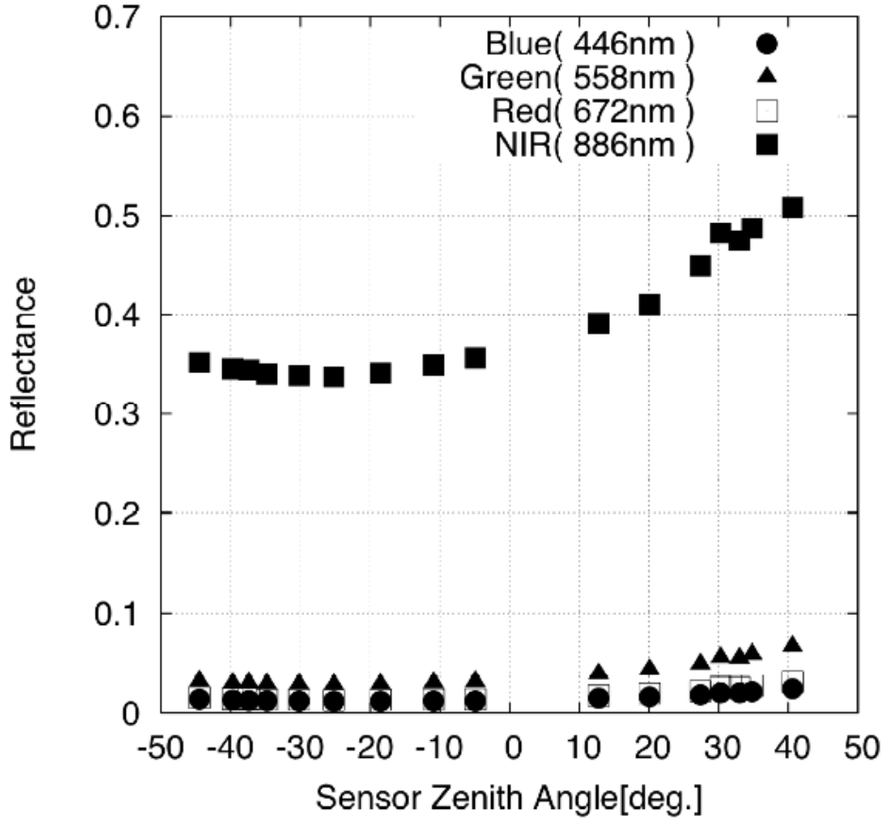

MS-720 S04042.03
EKO
MS-720

# BRDF Measurement Results



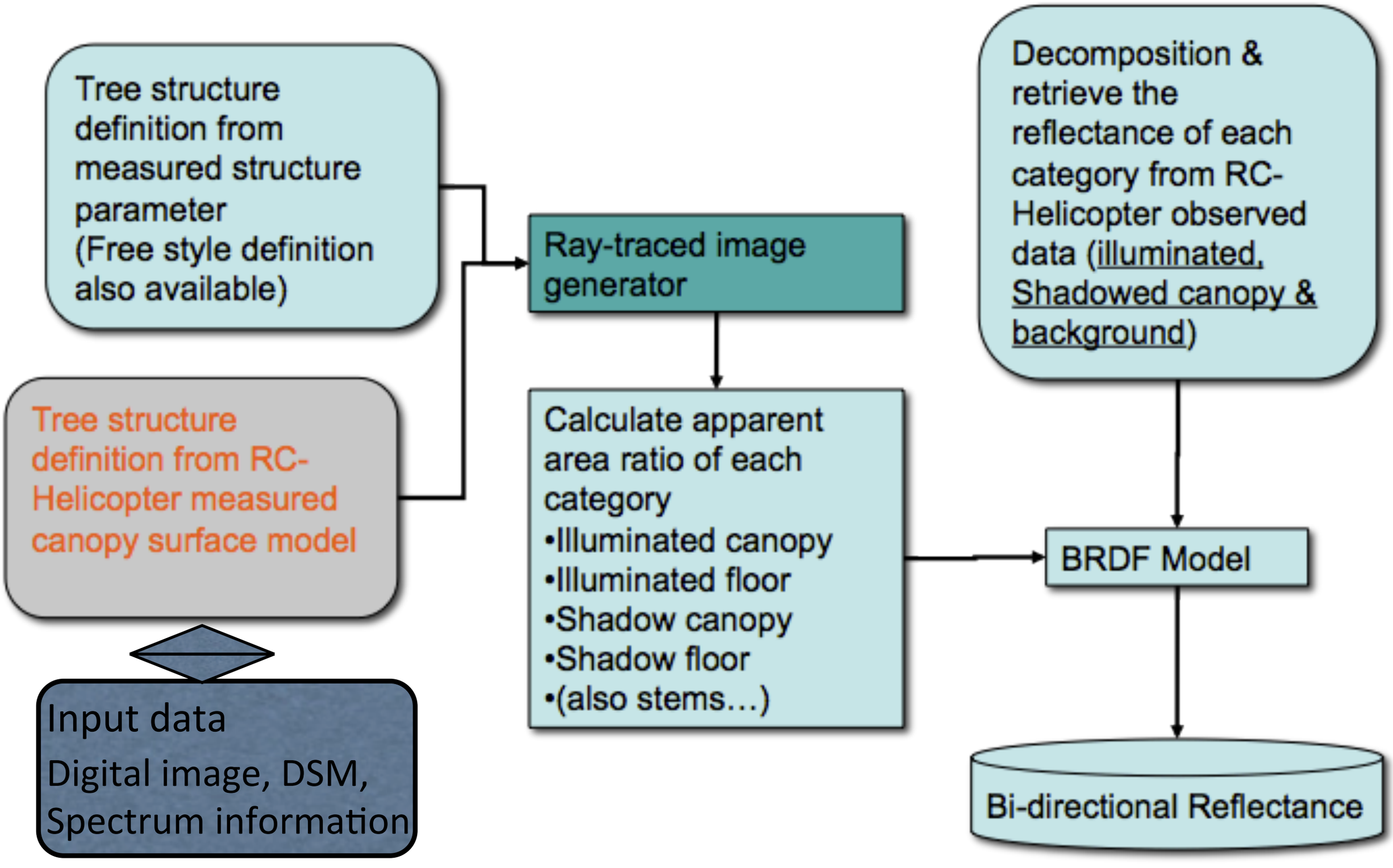

BRDF measurement flight pattern

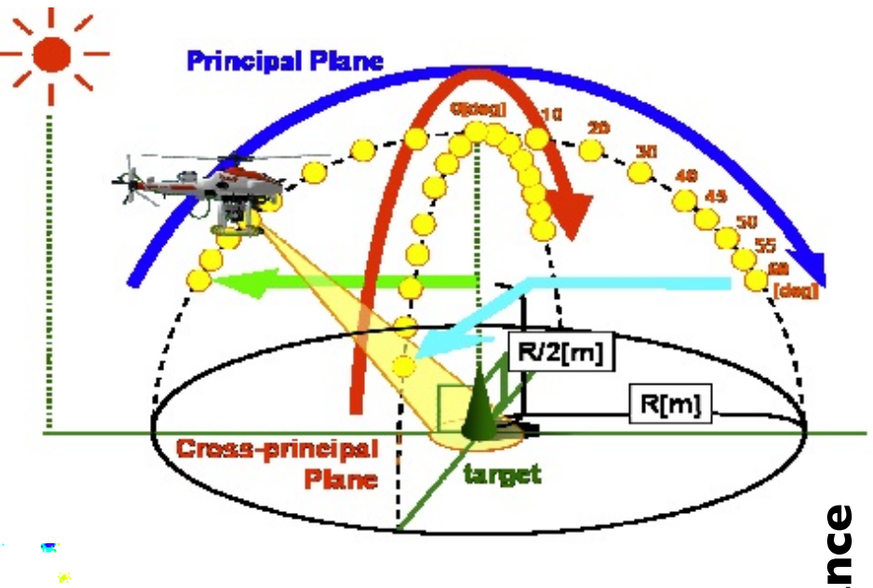


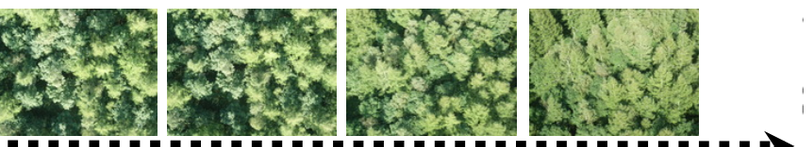




Measured BRDF

# Developed BRDF simulator

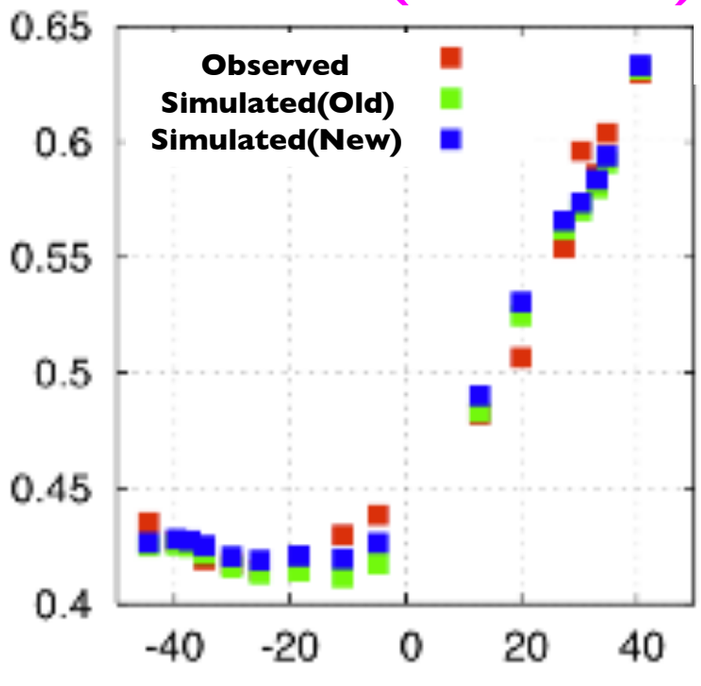




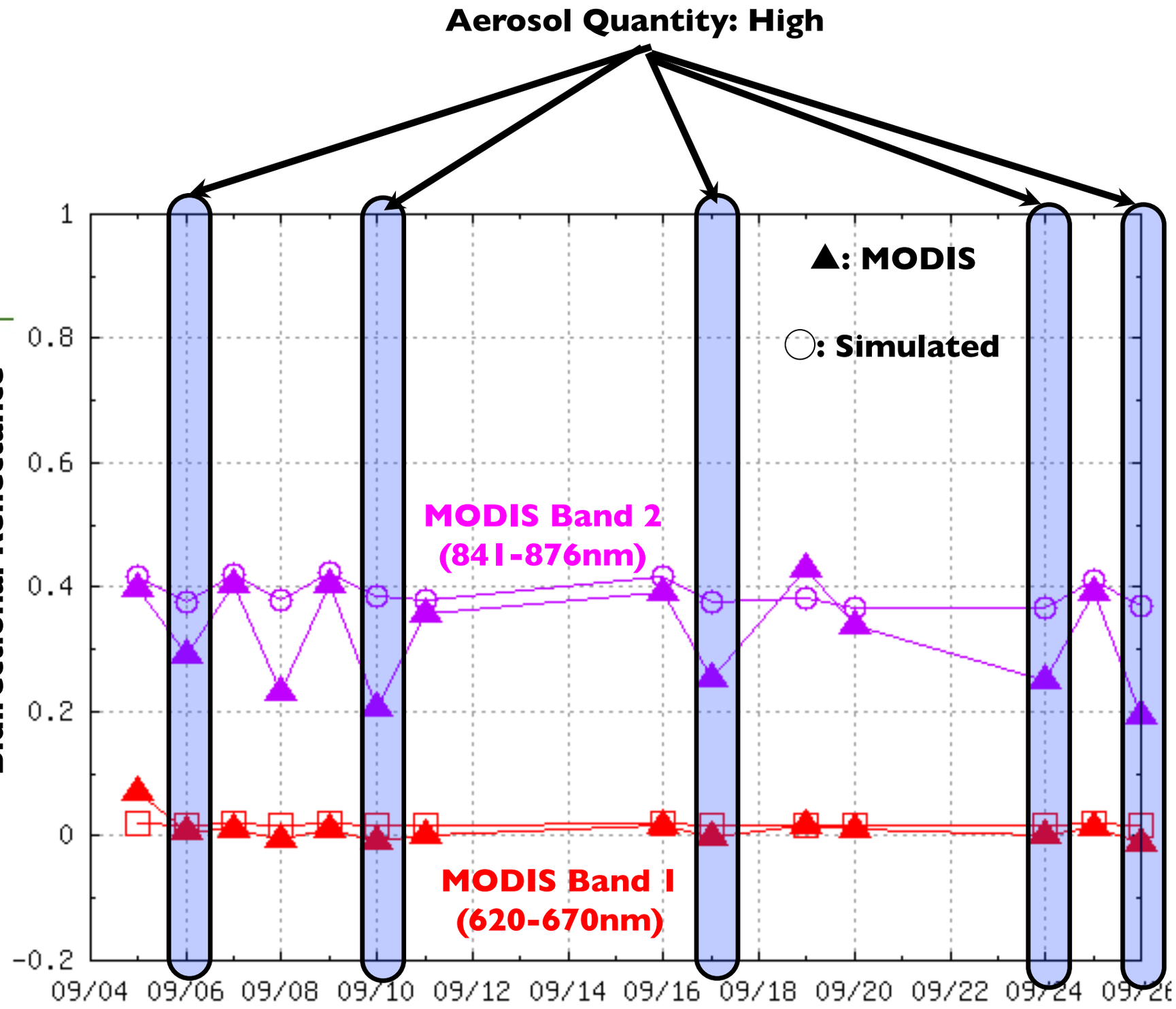
(Principal Plane)

MODIS Band 2(841-876nm)




***based on Field Observation]***

Aerosol Quantity: High




Date[Month/Day]

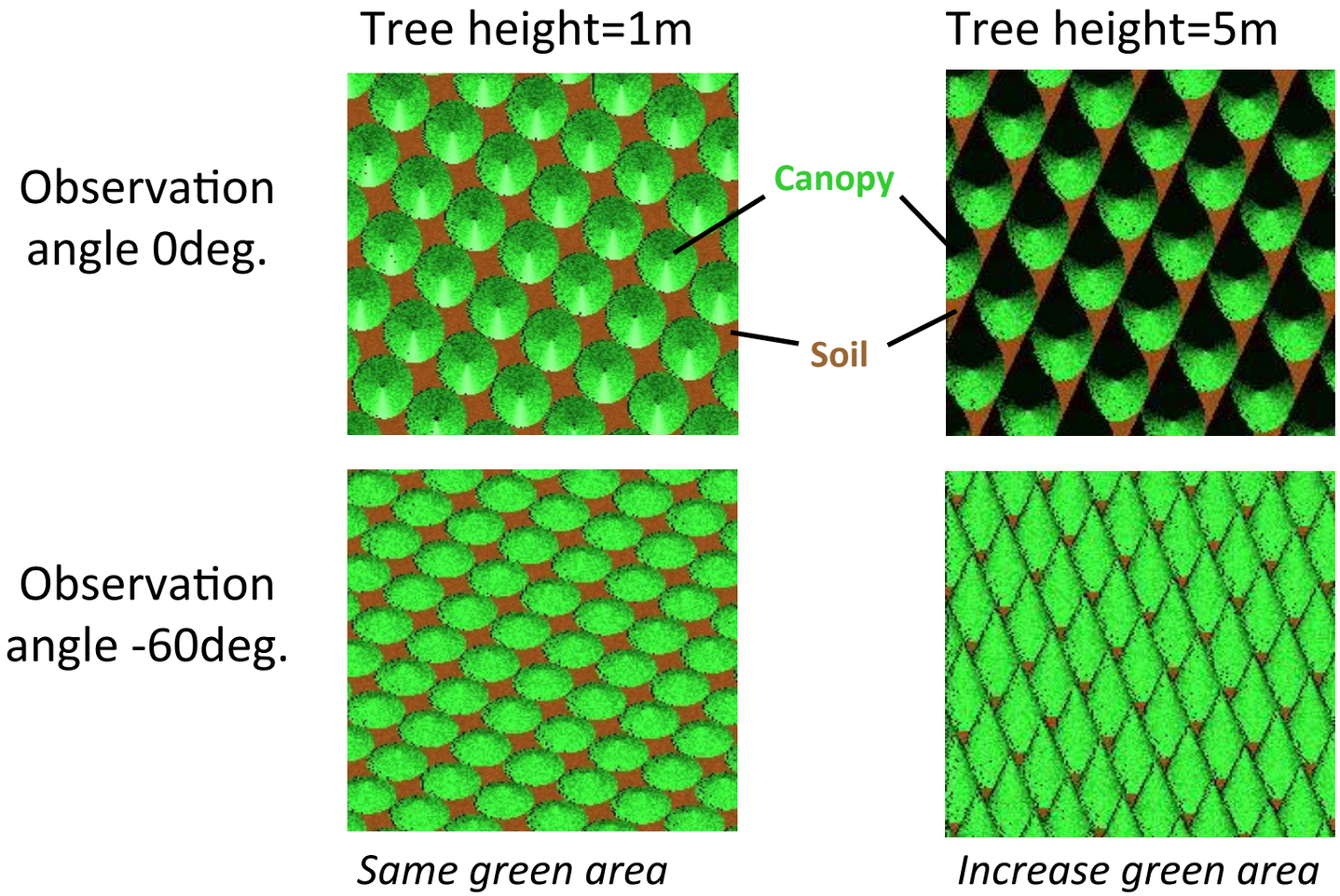
***[Verification of MODIS Product]***

# Contents

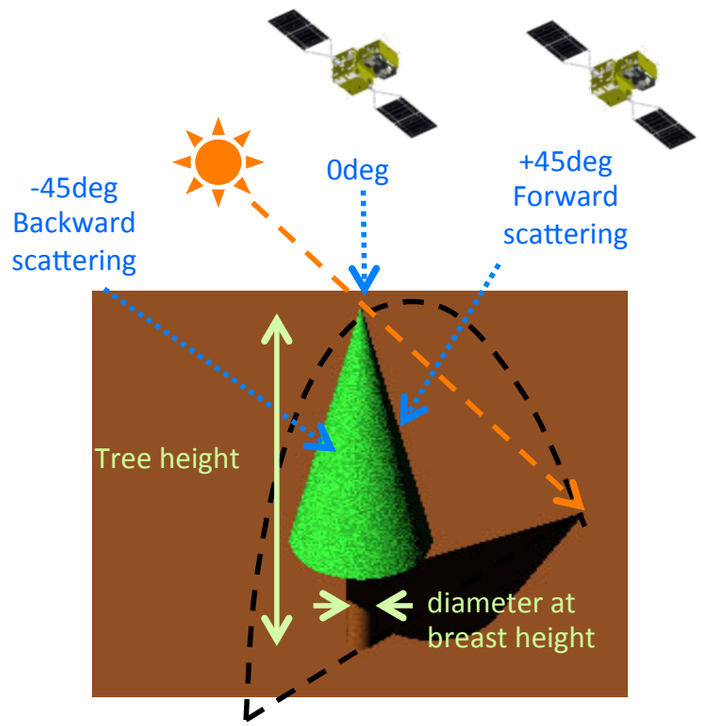
# 3. GCOM-C Observation Products

*Multi-angle observation for land cover and biomass estimation*

- *Reflectance change of slant and nadir observations will provide the information of the vertical structure of plants*
- *The information is used for land cover and above-ground biomass estimation*
- *The key scientific challenge is the radiative transfer of ground-vegetation-atmosphere*



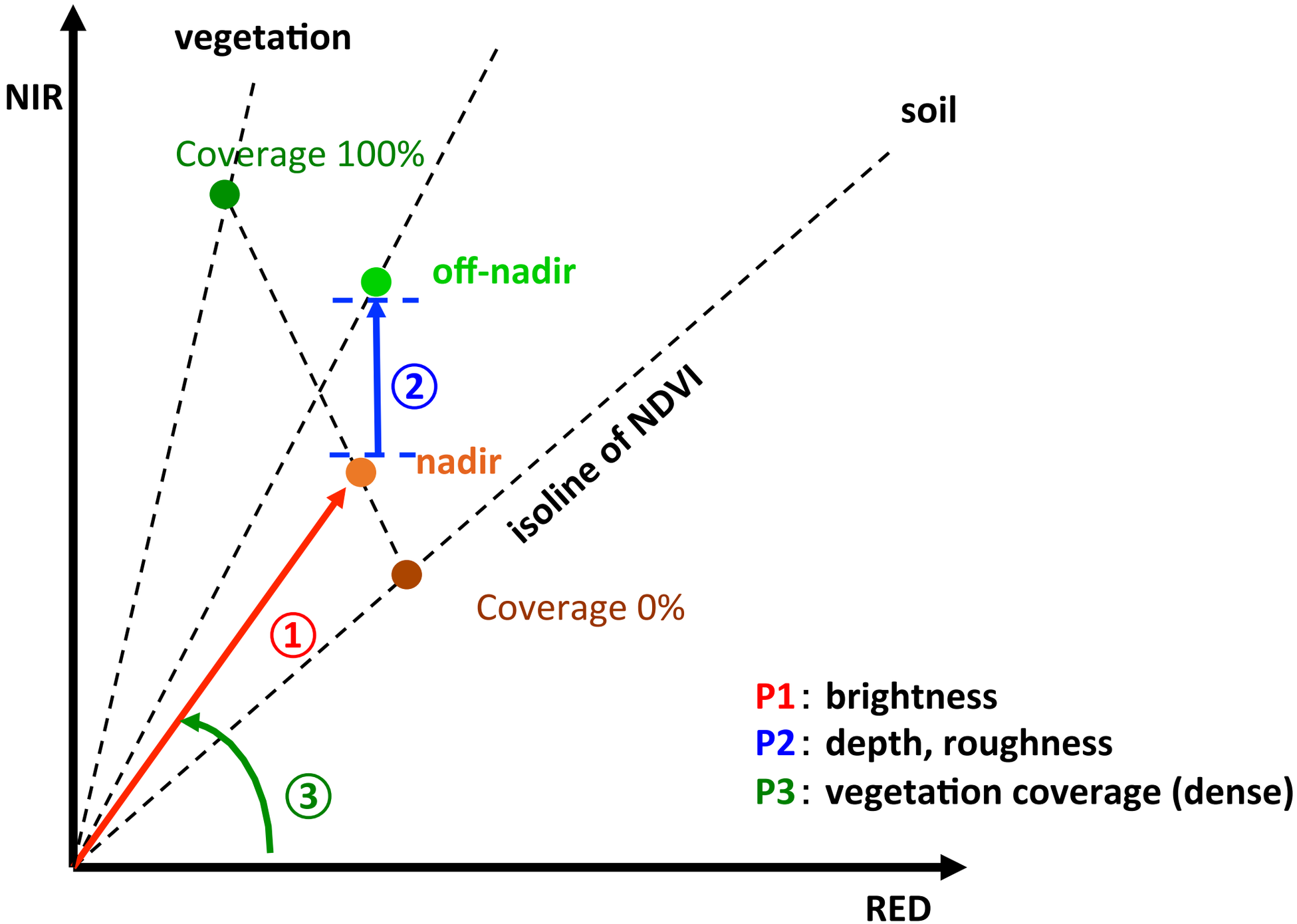

Reflectance change by the observation angles




Vegetation model
(Arboreal vegetation)

*Provided by Honda Lab. Chiba Univ.*

# Reflectance Shift in Red-NIR plane

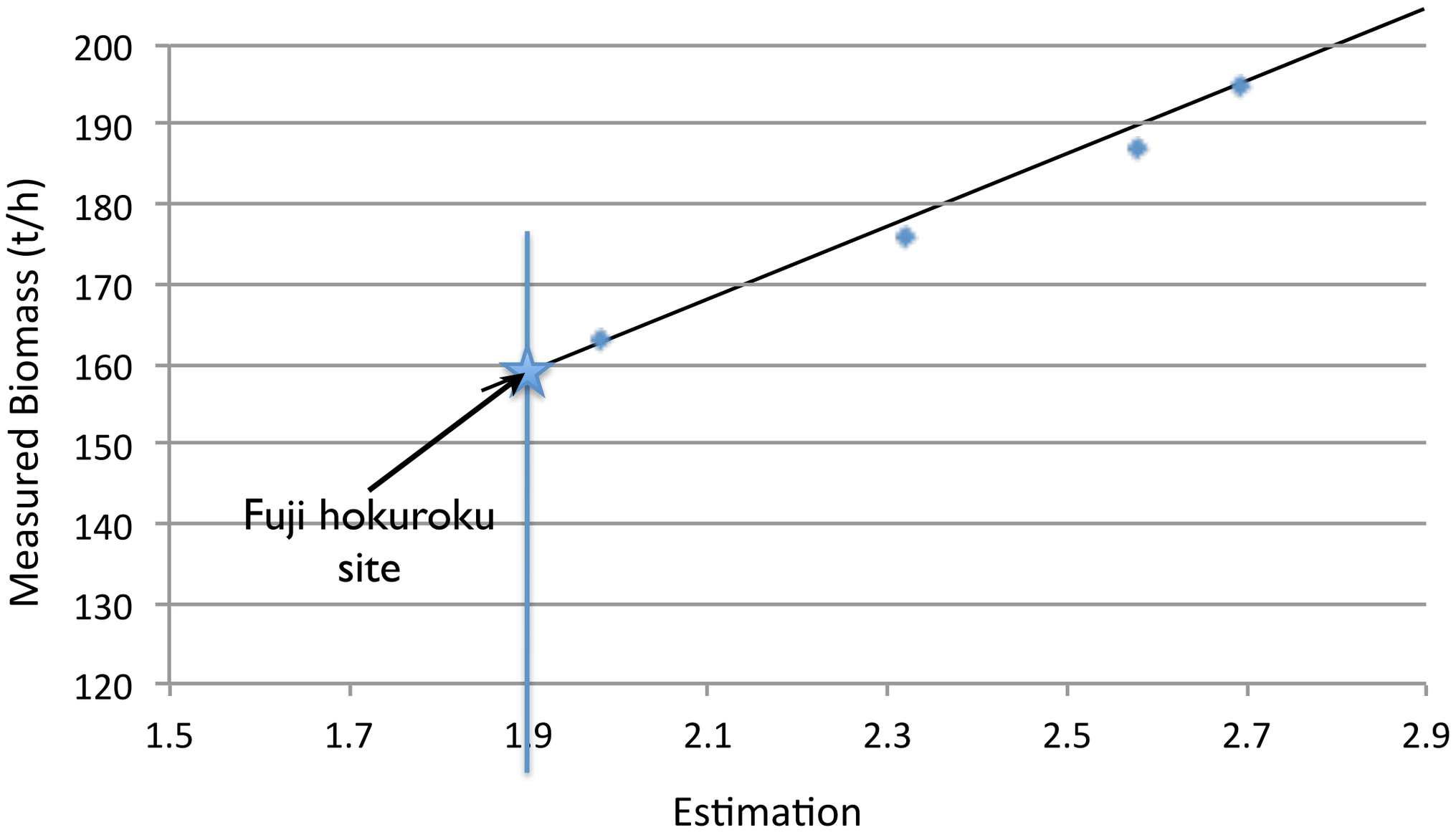


# Biomass Estimation using P1,P2,P3

$$AGB = \underbrace{C}_{\text{Forest Type Dependent Coefficient}} \cdot \underbrace{\left(\frac{P2}{P1} + 1\right)^{3}}_{\text{Volume related term}} \cdot \underbrace{P3}_{\text{Vegetation Coverage}}$$

- P1, P2, P3 should be used the reflectance on fixed geometry (normalized geometry).
- To obtain the P1, P2, P3 at fixed geometry, satellite observed reflectance has to simulate with BRDF model.

# Biomass Estimation Result for Larch forest

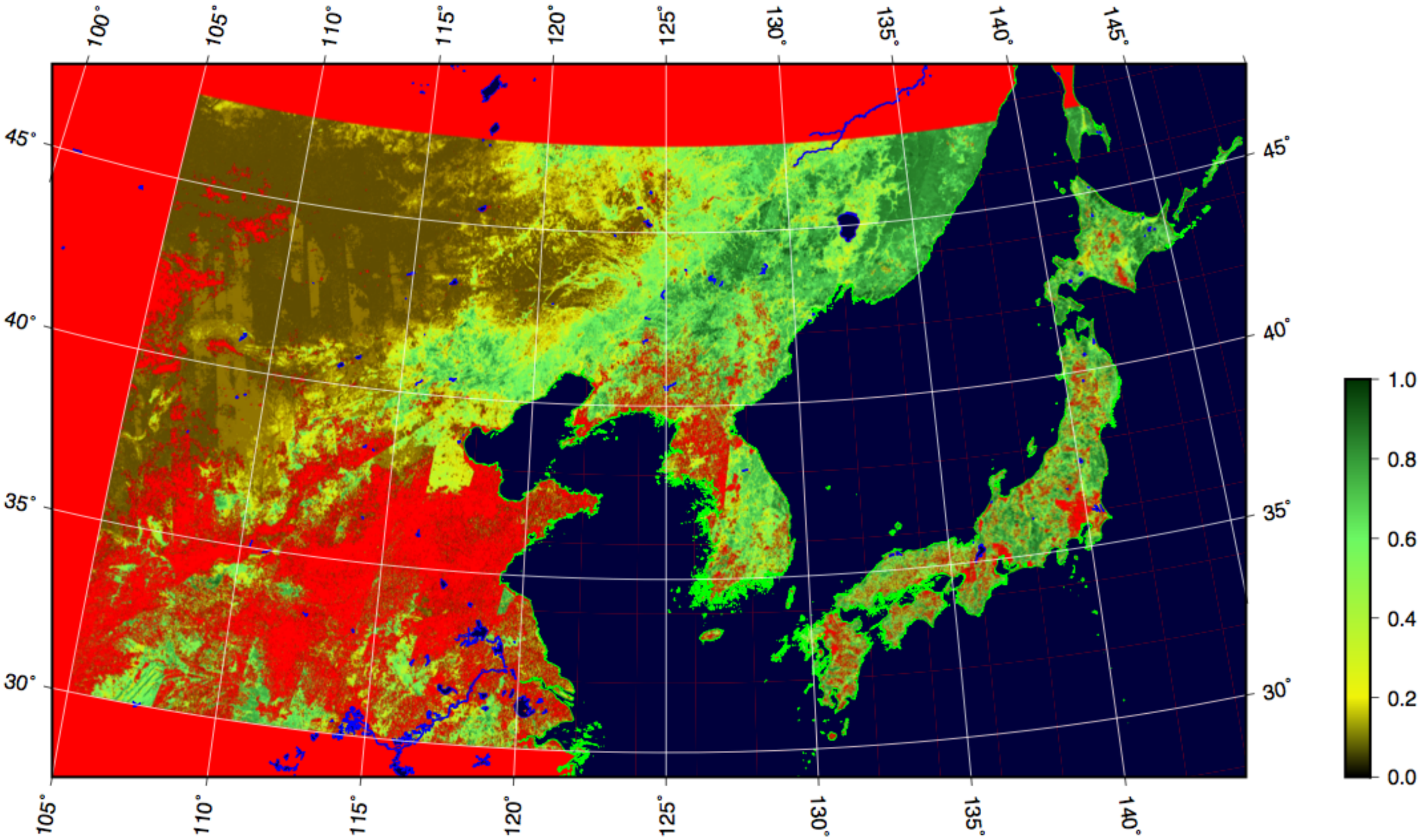



C=75.63

using MODIS swath overwrap

Mt. Yatsuga site

# Processing result for 2010 summer on East Asia (AGB)




Red color indicates invalid STSG/reflectance combination found or nadir NDVI < 0 pixel

Used data: MOD09GA(Terra), MYD09GA(Aqua) 7/1 to 9/30 (92 days maximum composite)

8 tiles: h25v04, h26v04, h26v05, h27v04, h27v05, h28v04, h28v05, h29v05

NDVI

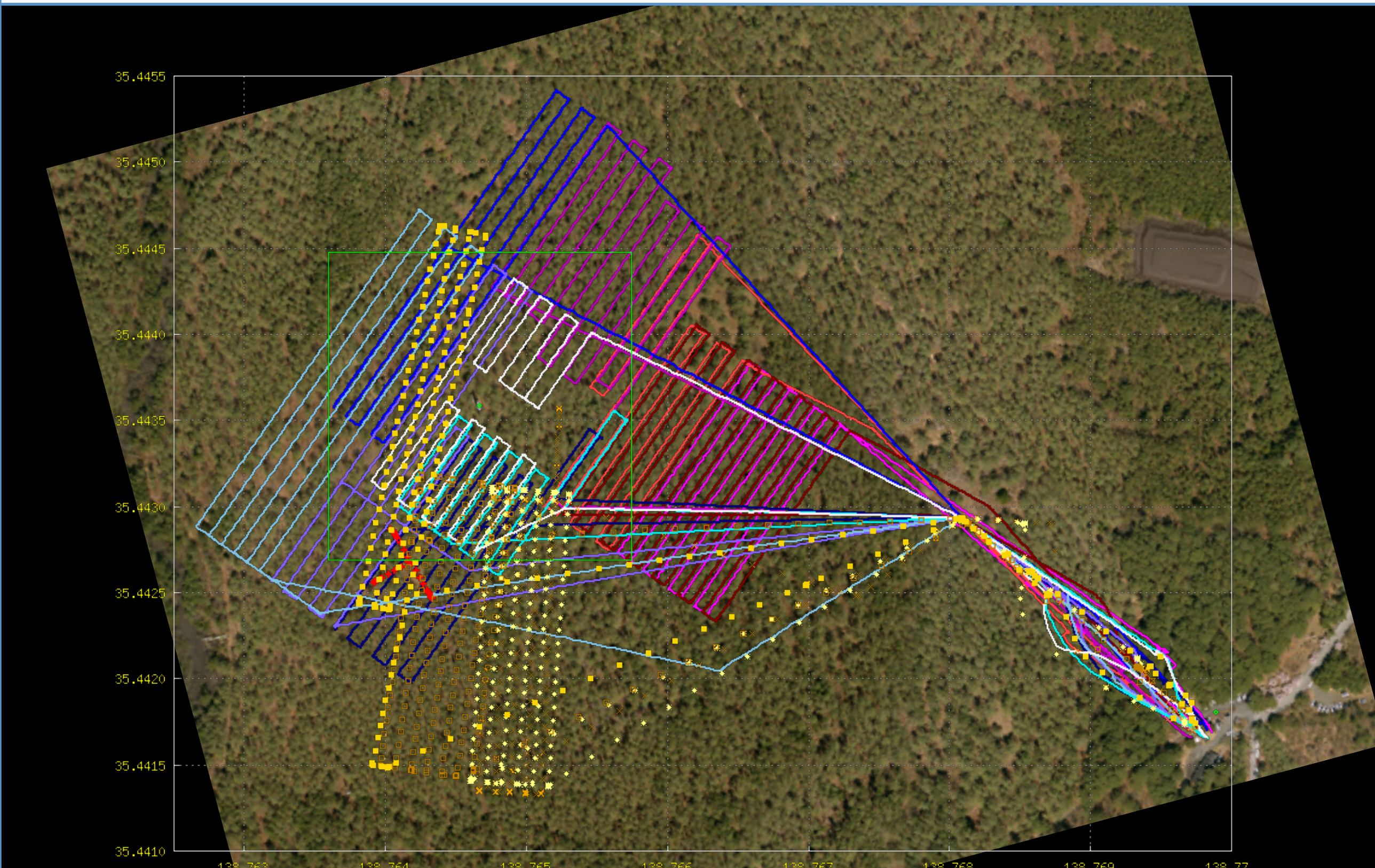
1.0
0.8
0.6
0.4
0.2
0.0


AGB

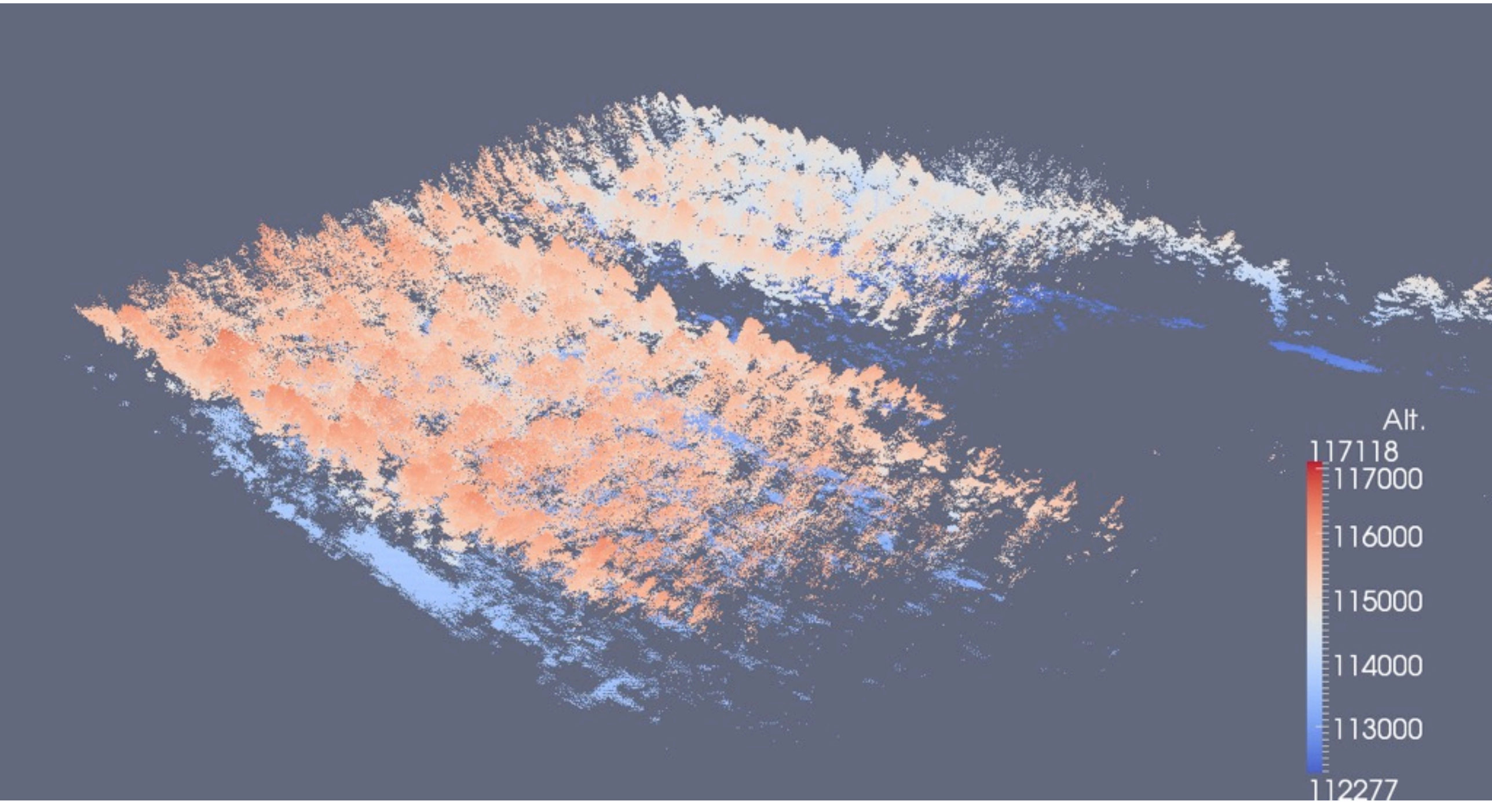
1.0
0.8
0.6
0.4
0.2
0.0

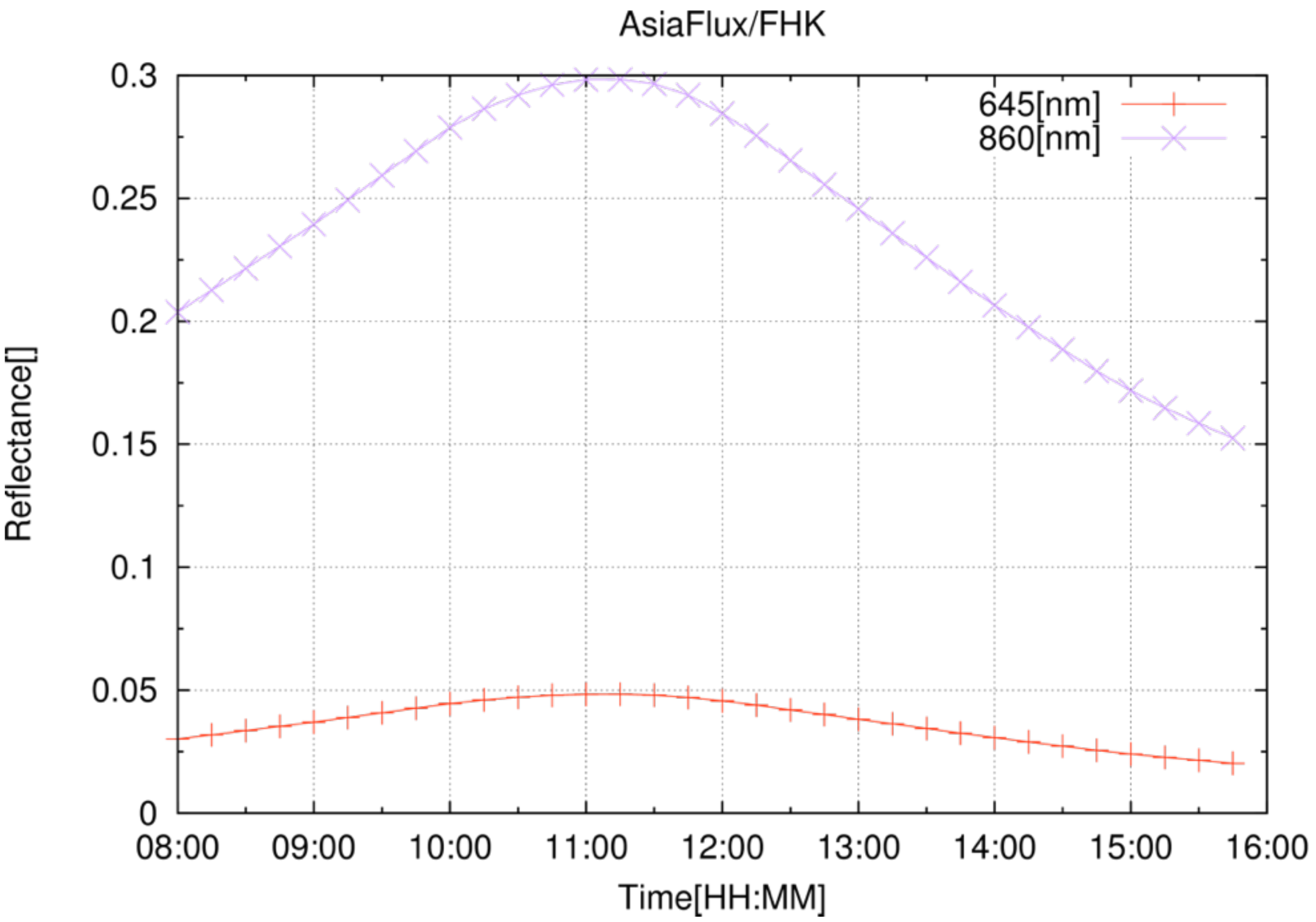
# Can a geostationary satellite provide BRDF data ?

# Helicopter Observation area (Fujihokuroku site)

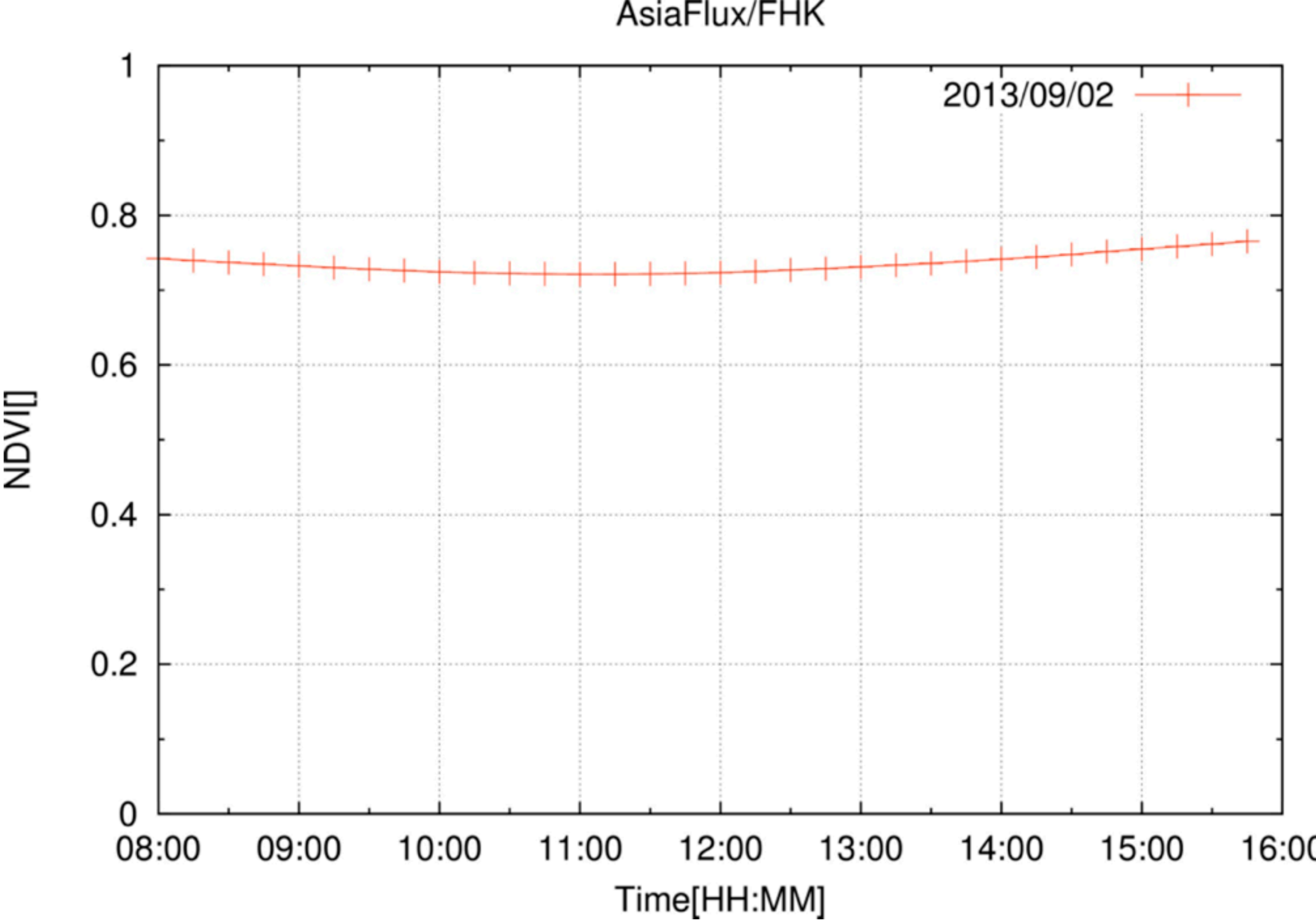


# Can a geostationary satellite provide BRDF data ?






Geostationary satellite can provide BRDF data




Geostationary satellite can provide BRDF data

# Conclusion

- All ATBD of the standard SGLI product are submitted from PIs. (Including Biomass product)
- Hardware and software preparation are going smoothly towards the launch in 2016.
- Geostationary satellite can provide BRDF data. The next generation HIMAWRI can provide BRDF data.

# Thank you

# for kind attention

Please visit

http://suzaku.eorc.jaxa.jp/GCOM_C/index.html