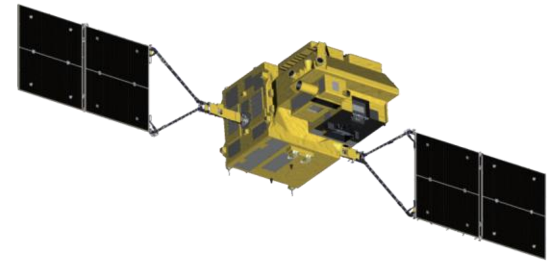

Potential of GCOM-C1/SGLI datasets for quantifying biomass and water stress

Koji Kajiwara*, Masao Moriyama**,
Yoshiaki Honda*, Hiroshi Murakami***
* Center for Environmental Remote Sensing, Chiba University, Japan
** Nagasaki University, Japan
***Earth Observation Research Center, JAXA, Japan

International Workshop on “Inventory, Modeling and Climate Impacts of Greenhouse Gas emissions (GHG’s) and Aerosols in the Asian Region”
II. Session topic: Earth Observation Programs in Land Cover/Land Use/Air Pollution/GHG emissions and Coordination Activities,
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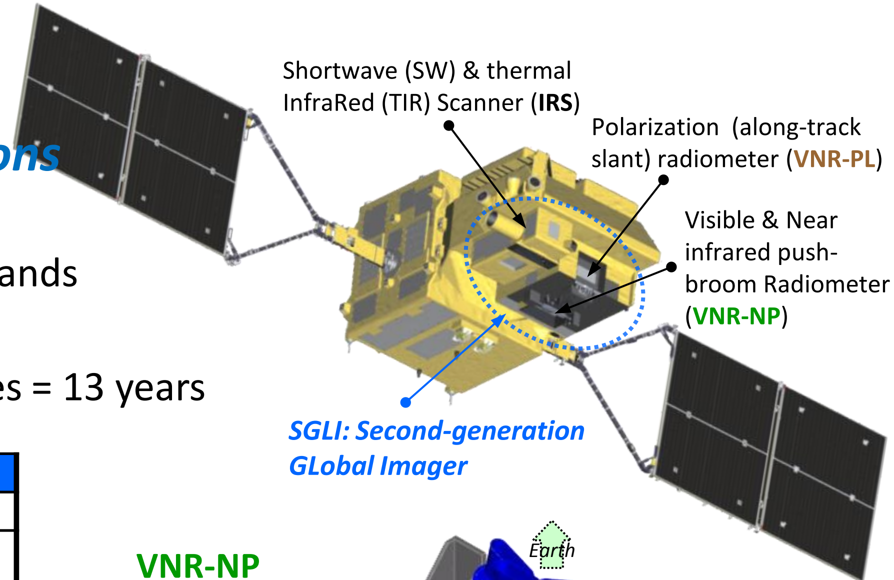
1. GCOM-C1/ SGLI

Global land, coastal, and aerosol observations

- ✓ 250m resolution with 1150~1400km swath
- ✓ Polarization/along-track slant view of Red and NIR bands
- ✓ Descending local time: AM10:30
- ✓ Launch in JFY2016 (TBD); 5-year lifetime × 3 satellites = 13 years



SGLI channels

CH	λ	Δλ	L_{std}	L_{max}	SNR at Lstd	IFOV
	VN, P, SW: nm T: μm		VN, P: W/m²/sr/μm T: Kelvin		VN, P, SW: - T: NEΔT	m
VN1	380	10	60	210	250	1k/250
VN2	412	10	75	250	400	1k/250
VN3	443	10	64	400	300	1k/250
VN4	490	10	53	120	400	1k/250
VN5	530	20	41	350	250	1k/250
VN6	565	20	33	90	400	1k/250
VN7	673.5	20	23	62	400	1k/250
VN8	673.5	20	25	210	250	1k/250
VN9	763	12	40	350	1200(@1km)	1k/250
VN10	868.5	20	8	30	400	1k/250
VN11	868.5	20	30	300	200	1k/250
PL1	673.5	20	25	250	250	1km
PL2	868.5	20	30	300	250	1km
SW1	1050	20	57	248	500	1km
SW2	1380	20	8	103	150	1km
SW3	1630	200	3	50	57	1k/250
SW4	2210	50	1.9	20	211	1km
TIR1	10.8	0.7	300	340	0.2	1k/500/250
TIR2	12.0	0.7	300	340	0.2	1k/500/250

1150km swath (VN1–VN11, PL1–PL2)

1400km swath (SW1–TIR2)

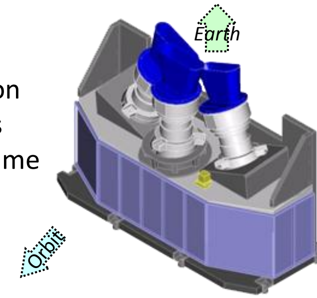
Multi-angle obs. for 674nm and 869nm (VN8, VN11, PL1, PL2)

250m over the Land or coastal area, and 1km over offshore

250m-mode possibility

VNR-NP

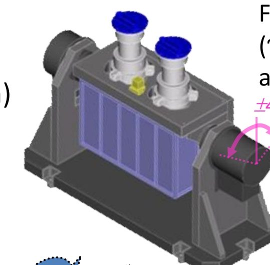
- Non-polarization tree telescopes
- Each has the same 11 channels
- Diffuser CAL



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

VNR-PL

- Polarization two (670nm and 865nm) telescopes
- Each has tree polarization-angle filters

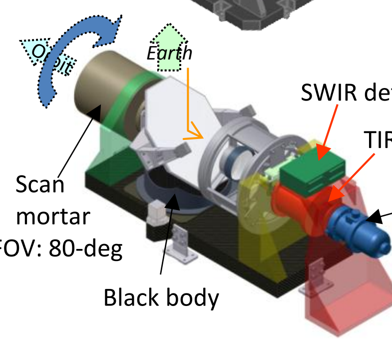


FOV: 55deg (~1150km@±45deg along-track slant)

±45deg along-track slant observation

IRS

- Ritchey-Chretien Optics
- 4 SWIR & 2 TIR channels
- Black body & diffuser CAL



GCOM-C1 / SGLI Land products

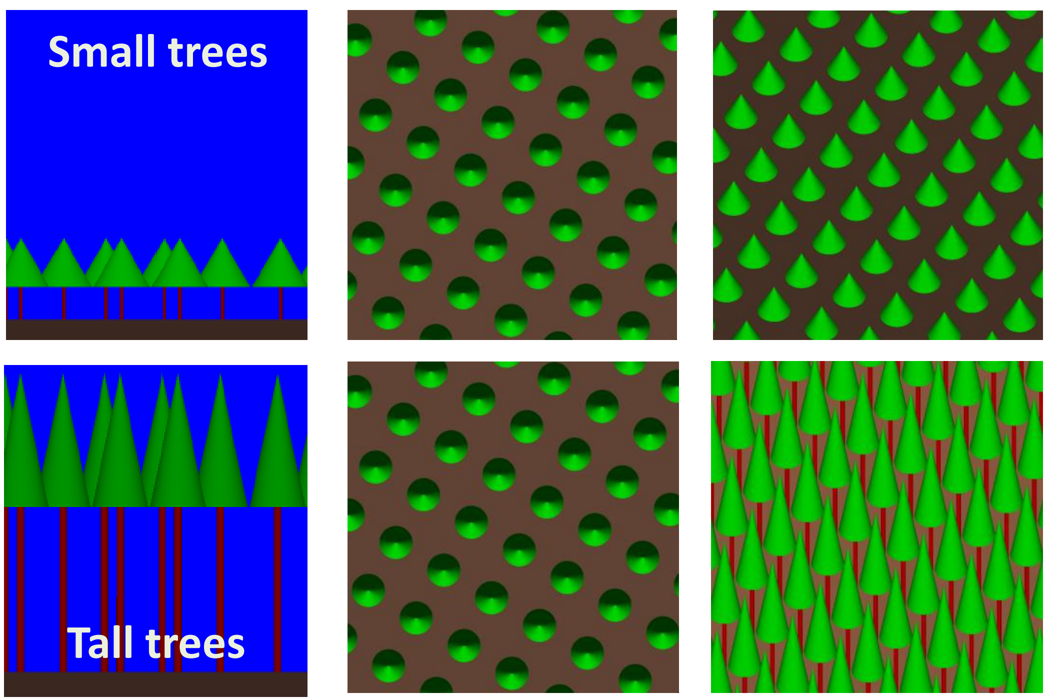
Area	Group	Product	Category	Developer	Day/night	Production unit	Grid size
Land	Surface reflectance	Precise geometric correction	Standard	JAXA	Both	Tile, Global (mosaic 1, 8 days, month)	250m
		Atmospheric corrected reflectance (incl. cloud detection)	Standard	JAXA	Daytime	Tile , Global (1, 8 days, month)	250m
	Vegetation and carbon cycle	Vegetation index	Standard	PI/JAXA	Daytime	Tile , Global (1, 8 days, month)	250m
		fAPAR	Standard	JAXA/PI			
		Leaf area index	Standard	JAXA/PI			
		Above-ground biomass	Standard	Kajiwara	Daytime	Tile , Global (1, 8 days, month)	1km
		Vegetation roughness index	Standard				1km
		Shadow index	Standard				250m, 1km
	Temperature	Surface temperature	Standard	Moriyama	Both	Tile , Global (1, 8 days, month)	500m
	Application	Land net primary production	Research	Nasahara	Daytime	Global (month, year)	1km
		Water stress trend	Research	Kajiwara	N/A	Tile , Global (1, 8 days, month)	500m
		Fire detection index	Research	Moriyama | Nakau	Both*12	Scene or Tile	500m
		Land cover type	Research	Fukue | Soyama /Takagi	Daytime	Global (month, season)	250m
		Land surface albedo	Research	JAXA/PI	N/A	Tile , Global (1, 8 days, month)	1km

- ✓ Land cover → emission types such as fire, dust, VOC..
- ✓ Above-ground biomass → potential emission by fire
- ✓ Surface temperature and water stress trend → dust and fire events

2. Multi-Angle Observation for Land Cover & Biomass Estimation

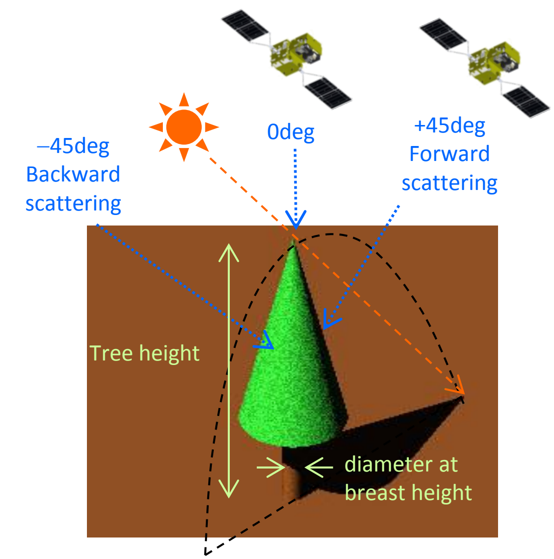
- Reflectance change of slant and nadir observations will provide the information of the vertical structure of plants
- The information is used for land cover and above-ground biomass estimation
- The key scientific challenge is the radiative transfer of ground-vegetation-atmosphere

Nadir view Slant view



Same green area *Increase green area*

Reflectance changes by the observation angles



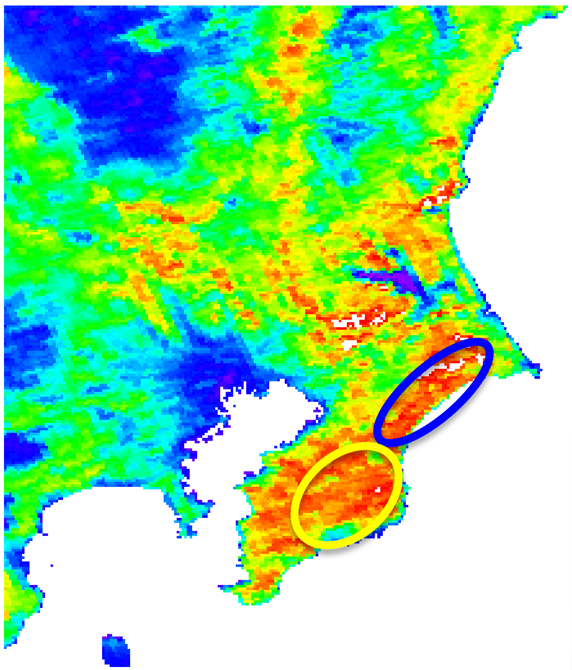
Vegetation model
(Arboreal vegetation)

Provided by Honda Lab.
Chiba Univ.

PI: Kajiwara

Land Cover

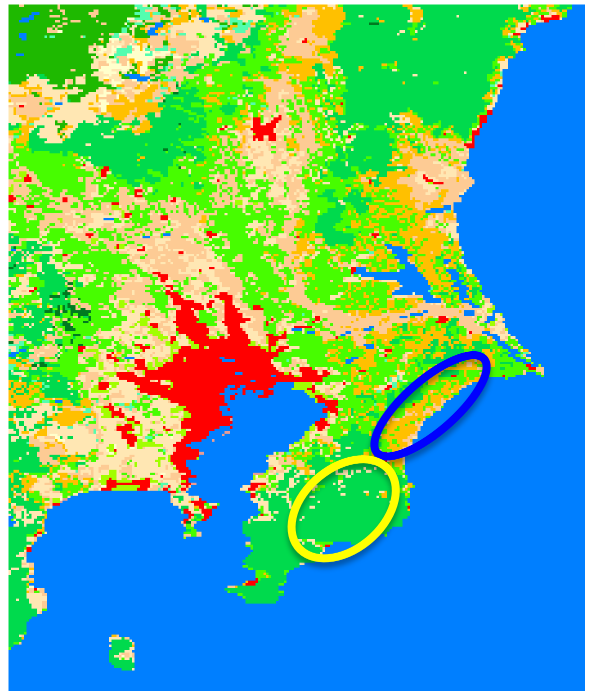
distinguish Forest – non Forest area by SGLI multi-angle observation



0 0.5

NDVI Image

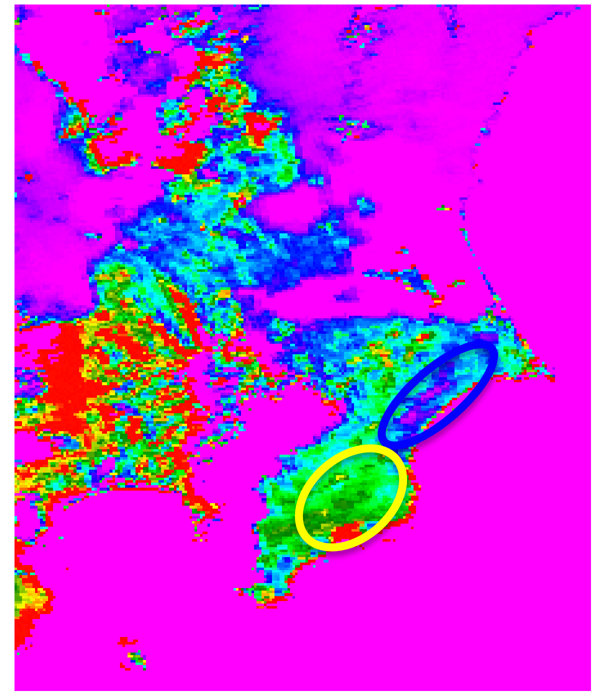
One shot TERRA/MODIS data



- Evergreen Br.Forest
- Deciduous Br.Forest
- Mixed Forest
- Dense shrub
- Shrub
- Woody sabana
- Grassland
- Paddy field
- Cropland (Non-paddy)
- Urban area
- Crop/natural Veg.
- Barren/Sparsely Veg.
- Water area

Land Cover Map

(Global Map / ISCGM)



0 1.0 2.0

Vegetation Roughness Index

Using Different view angle data

$$VRI = \frac{NIR_{slant} - Red_{slant}}{NIR_{nadir} - Red_{nadir}}$$

PI: Kajiwara

Above-Ground Biomass (ABG)

Daily SGLI 1km tiled / Atms. Corr. reflectance

- Nadir reflectance
- Slant view reflectance

↓

Extract valid Sun-Target-Sensor Geometry combination

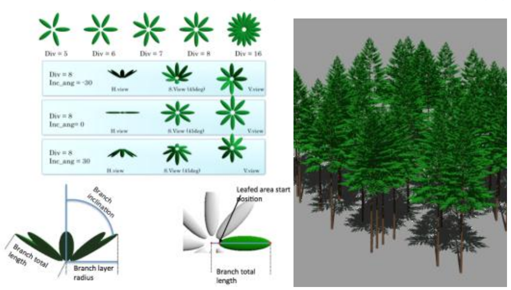
↓

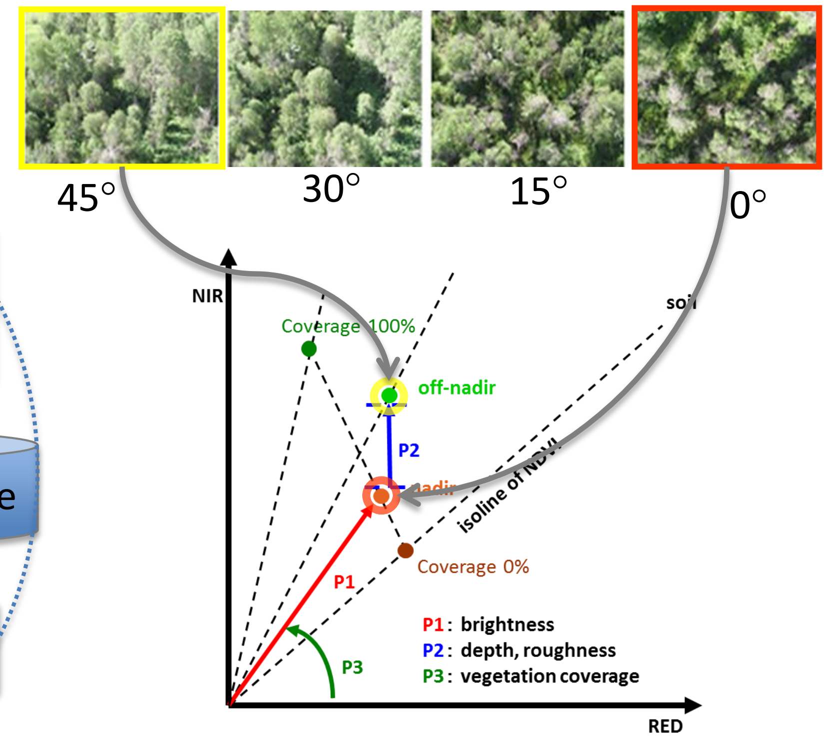
Above-Ground Biomass estimation ← Land cover data (Forest type); BRDF lookup table; DEM/Slope data

↓

Above-Ground Biomass data (1km tiles)

Canopy radiative transfer for each canopy structure type





$$AGB = C \cdot \left(\frac{P2}{P1} + 1 \right)^3 \cdot P3$$

- C: Forest-type Dependent Coefficient
- $\left(\frac{P2}{P1} + 1 \right)^3$: Volume related term
- $P3$: Vegetation Coverage

PI: Kajiwara

Simulation condition of the AGB lookup table

- Solar Zenith Angle : 0 to 80 , 10 deg. interval (9)
- Sensor Zenith Angle : 0 to 55, 5 deg. interval (12)
- Relative Zenith Angle : 0 to 180, 10 deg. interval (19)

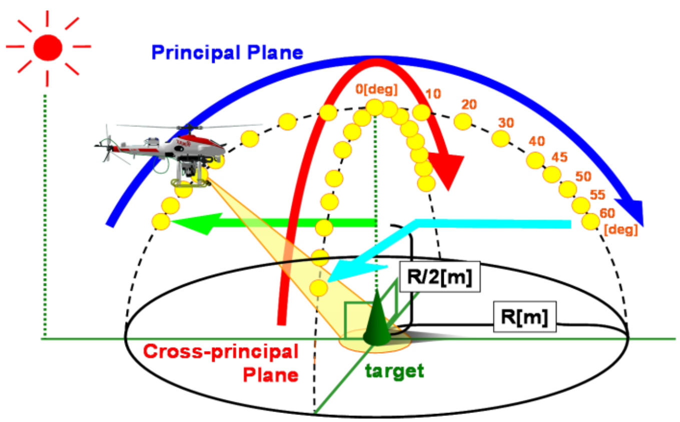
- Adjacent Tree Distance : 3.87m, 6.44m, 12.55m, 18.00 (4)
- Tree Height : 5m to 30m, 5m interval (6)
- Crown Depth = TH* cd : cd = 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8 (7)

- Total combination number = 9 * 12 * 19 * 4 * 6 * 7
  = 344,736
  for 1 forest canopy type.
- Currently,
  - Only one lookup table which represent larch forest is available
  - **Available forest types will be increased by cooperation with in-situ observation activities**

PI: Kajiwara

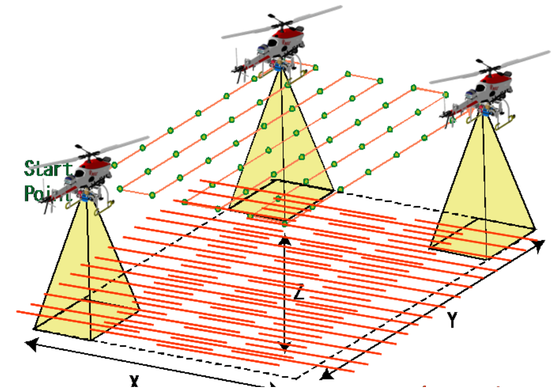
Validation of Above-Ground Biomass estimation:

Unmanned helicopter measurement for collecting BRF, canopy structure parameter / DSM

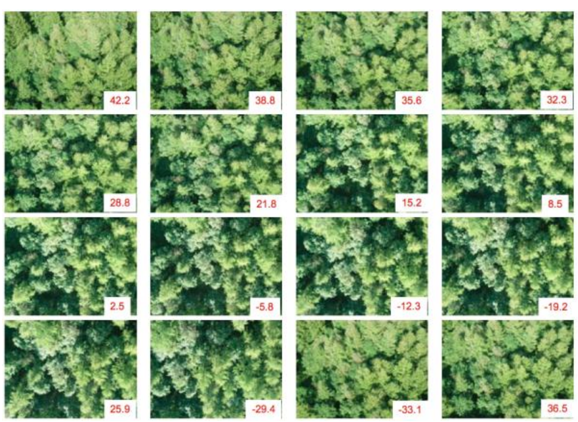


BRF measurement

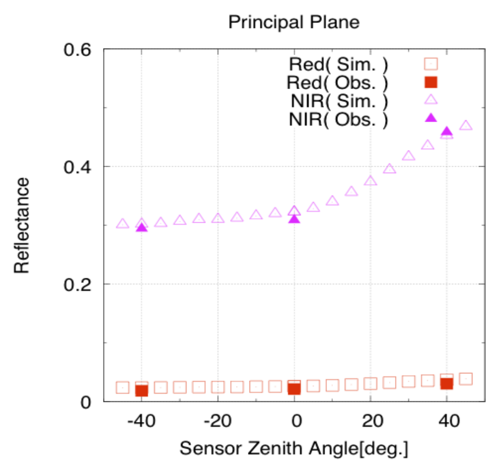
Unmanned helicopter



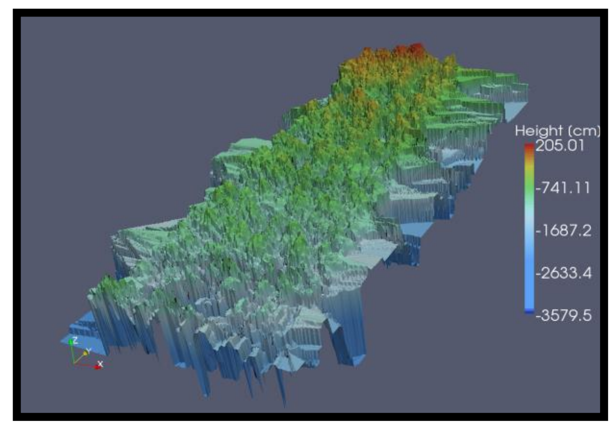
Canopy structure measurement using scanning LIDER



Examples of photos over the target area from multiple observation angles



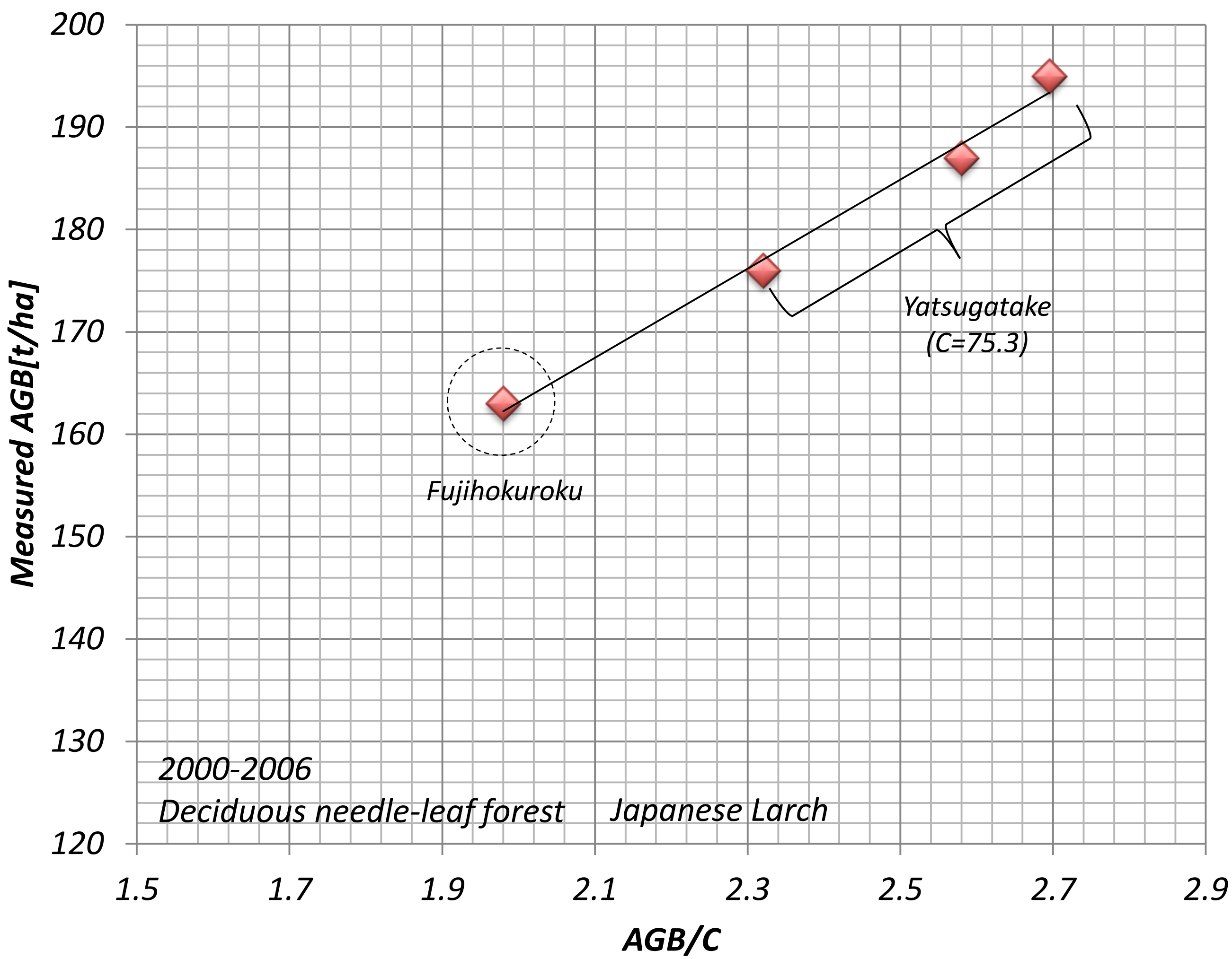
Canopy-top reflectance comparison between simulation and observation



Canopy DSM

PI: Honda, Kajiwara, in collaboration with observation networks

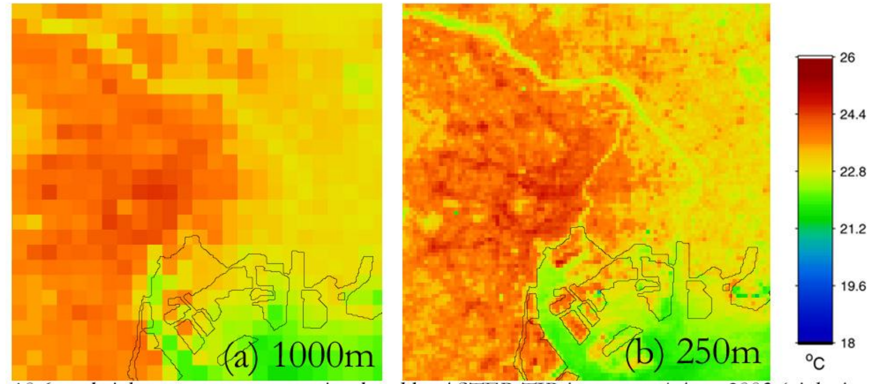
Algorithm Validation using in-situ measurement data



PI: Kajiwara

3. Land Surface Temperature (LST)

- ✓ **SGLI will have 250m/500m TIR observation**



10.6μm brightness temperature simulated by ASTER TIR image on 4 Aug. 2003 (nighttime)

- ✓ **Difficulty of LST estimation**

$$I = \tau(\theta)[\varepsilon B(T_s) + (1-\varepsilon)F/\pi] + I_a$$

Obs. radiance (I); Transmittance ($\tau(\theta)$); Emissivity (ε); LST (T_s); Downward irradiance at the surface (F); Path radiance (I_a)

(# of unknowns)> (# of formulae) →underdetermine

- ✓ **Conventional LST estimation algorithm**
  - Split window
    - Multiple regression.
    - Emissivity has to be known
    - MODIS, AATSR
  - Semi-analytical
    - With atm. Correction
    - Add the empirical formula and solve
    - ASTER

LST estimation algorithm for SGLI

- **Semi analytical algorithm**
  - ✓ Split band (10.8, 12.0[μm])
  - ✓ Additional formula: Split window
  - ✓ Objective analysis data for the radiative transfer parameters ($\tau_{1,2}$, $F_{1,2}$, $I_{a1,2}$, $C_{0\text{-}6}$, $r_{1,2}$)
  - ✓ Minimize the following formulae (Newtonian iteration).

$$B_1^{-1}\{\tau_1(\theta)[\varepsilon_1 B_1(T_s) + (1-\varepsilon_1)\frac{F_1}{\pi}] + I_{a1}(\theta)\} - T_1 = 0$$

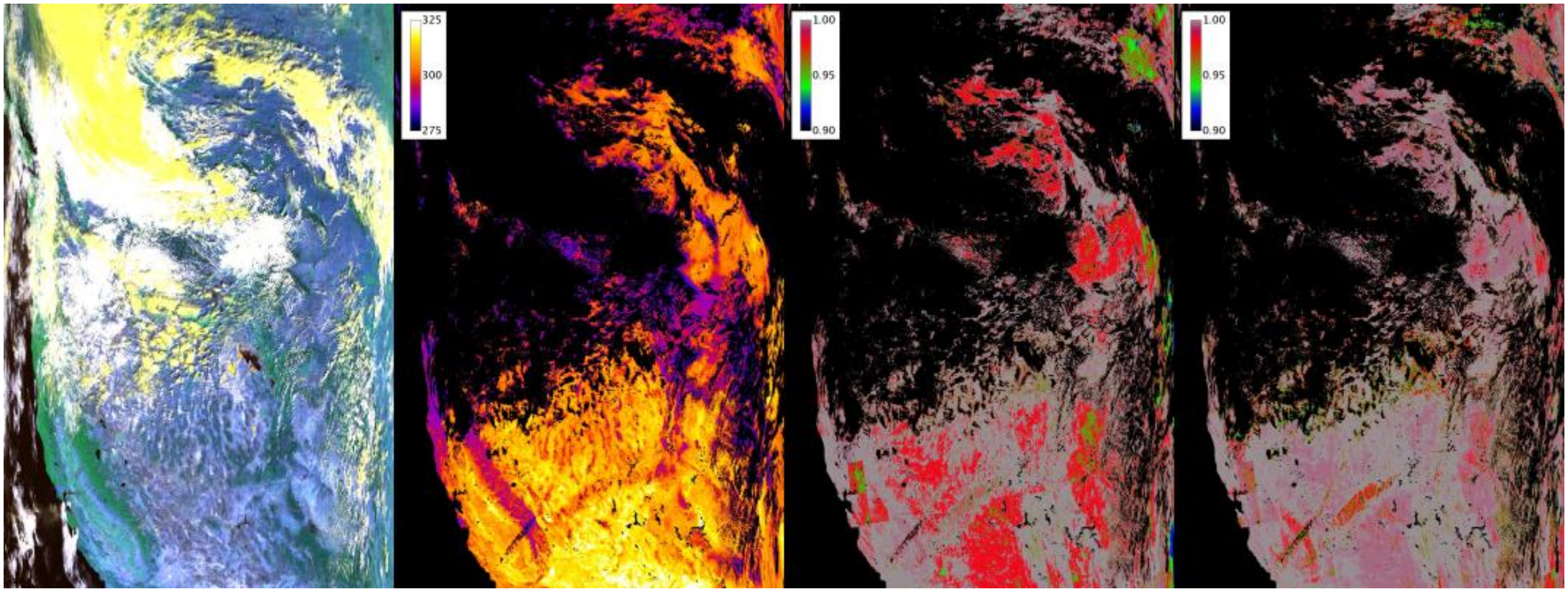
$$B_2^{-1}\{\tau_2(\theta)[\varepsilon_2 B_2(T_s) + (1-\varepsilon_2)\frac{F_2}{\pi}] + I_{a2}(\theta)\} - T_2 = 0$$

$$C_0 + (C_1 + r_1 C_2)T_1 + C_3 r_1 + (C_4 + r_2 C_5)T_2 + C_6 r_2 - T_s = 0, \quad (r_i = 1 - \varepsilon_i)$$

PI: Moriyama

LST estimation example

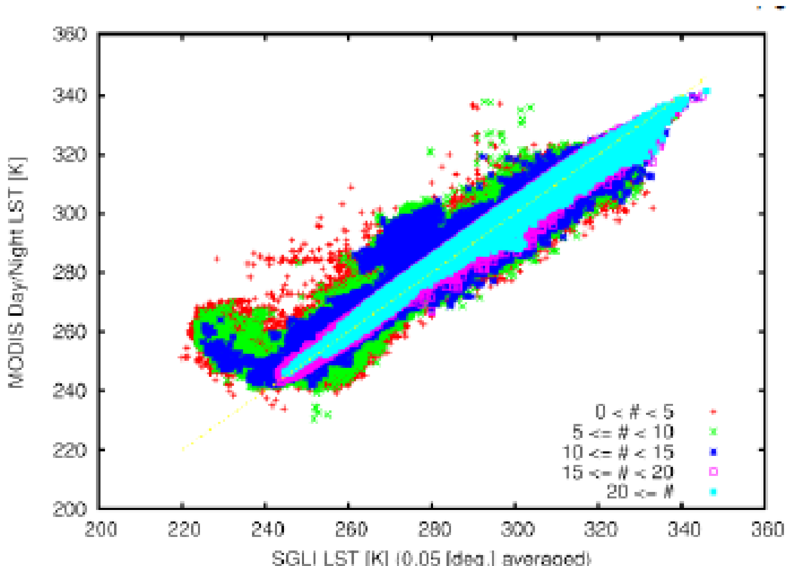
False color(126) LST Emissivity (10.8) Emissivity (12.0)



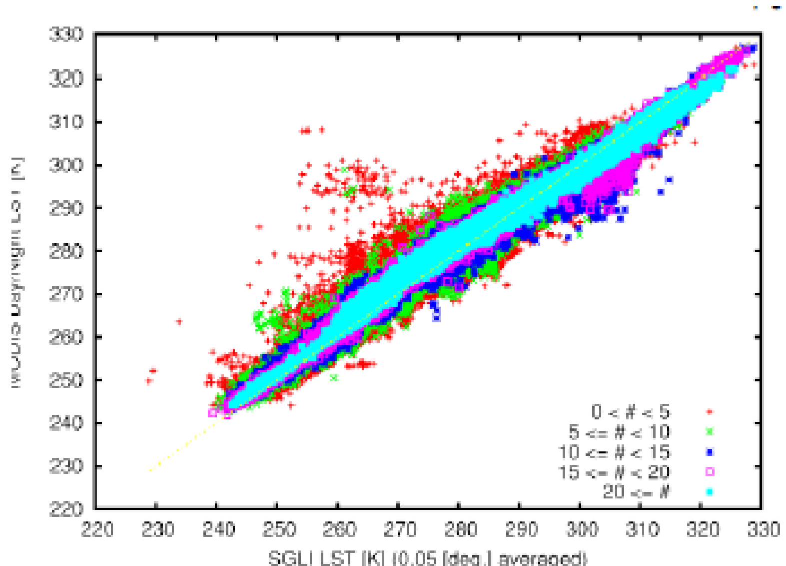
- Terra/MODIS 2008/09/21, 18:35Z, US west coast
- Atm. data: NCEP d082 (1deg. mesh)
- Computation time: ≈20min. (Core2duo 2.2GHz)

PI: Moriyama

LST Validation



1835Z BIAS: -0.92[K], RMS: 2.02[K]



0400Z BIAS: -1.01[K], RMS: 1.63[K]

- Comparison with MOD11C1 (Day/Night LST, 0.05deg.)
- LST estimation from MOD021KM data acquired at 1835Z and 0400Z from 2000 to 2013.
- Average the estimated LST into 0.05deg. and compare.

PI: Moriyama

4. Water Stress Trend

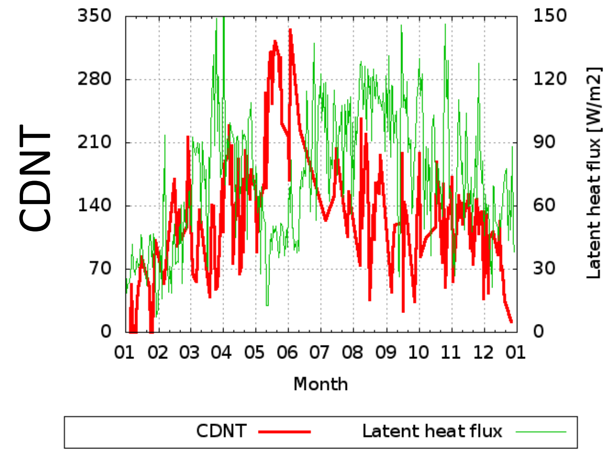
by Compensated Day/Night Temperature difference (CDNT)

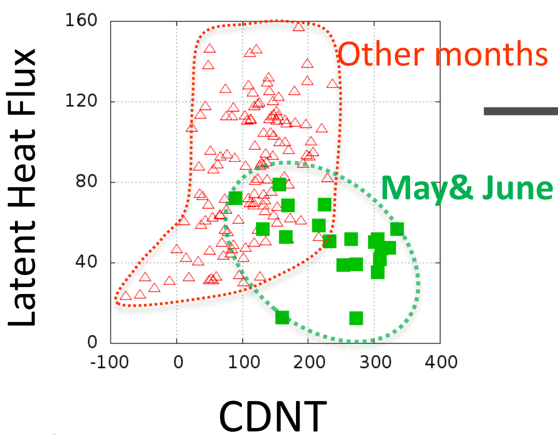
CDNT = (T_{day} – T_{night}) × T_{night} (*T* in [deg. C])

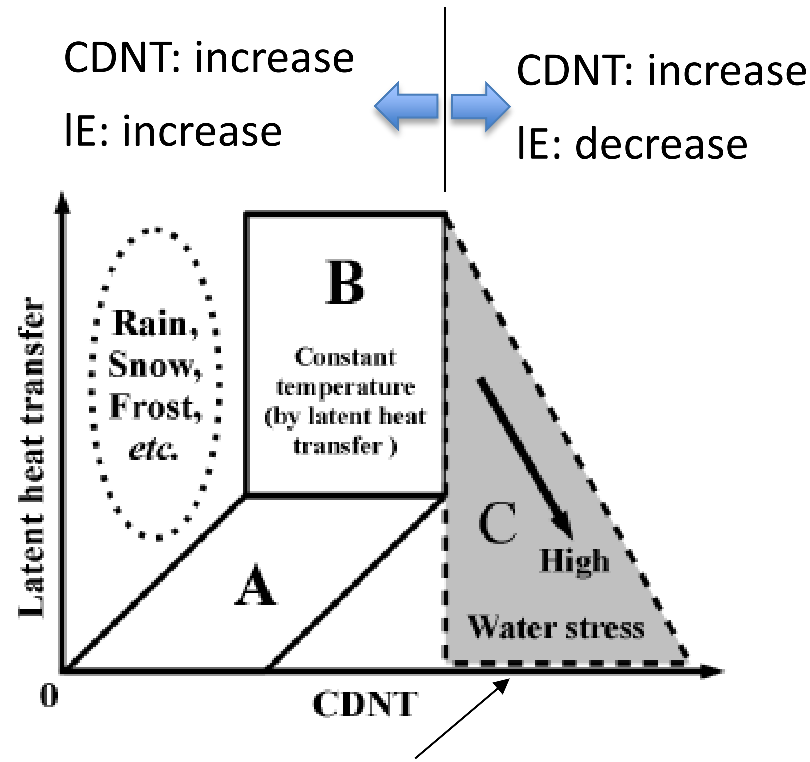
Basic concept

$T_{day} - T_{night}$: large at forest
→Water stressed

Donaldson, FL 2001 Ameriflux data







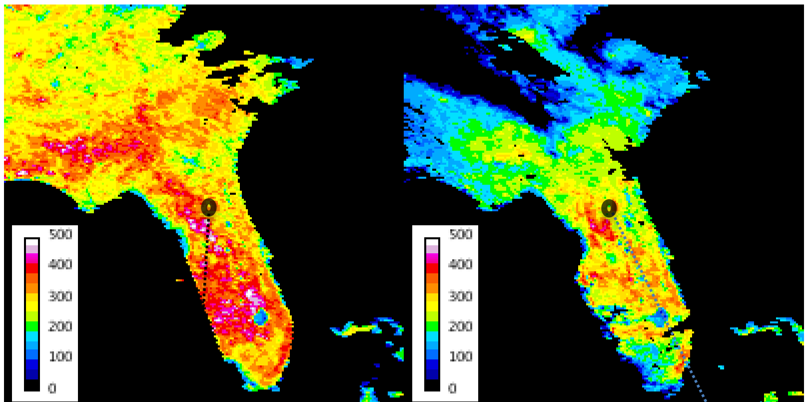
Extremely high CDNT= water stressed

PI: Moriyama

CDNT from satellite data

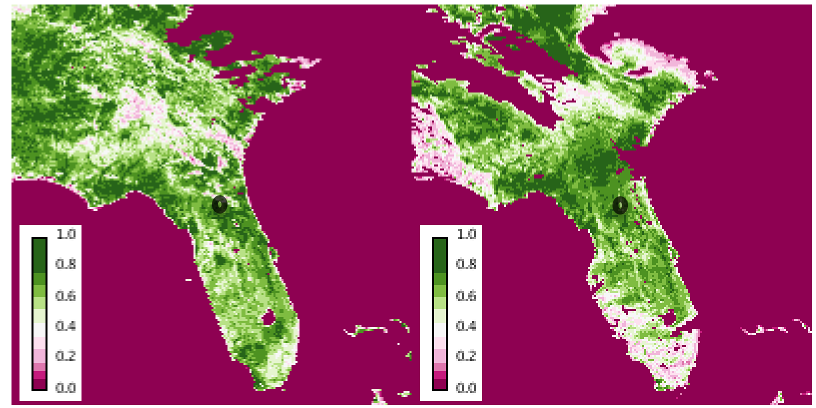
CDNT

2001 May 17   2003 May 4



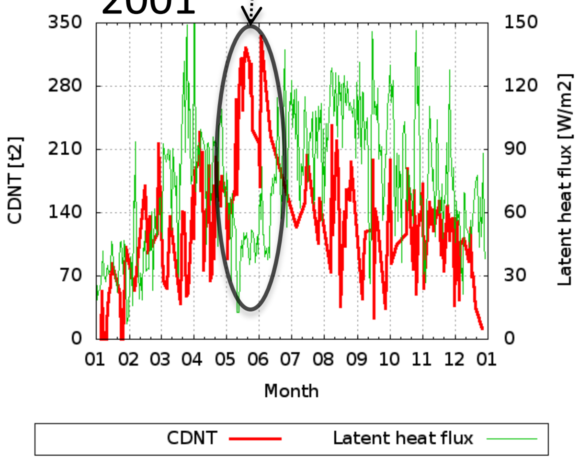
NDVI

2001 May 17   2003 May 4

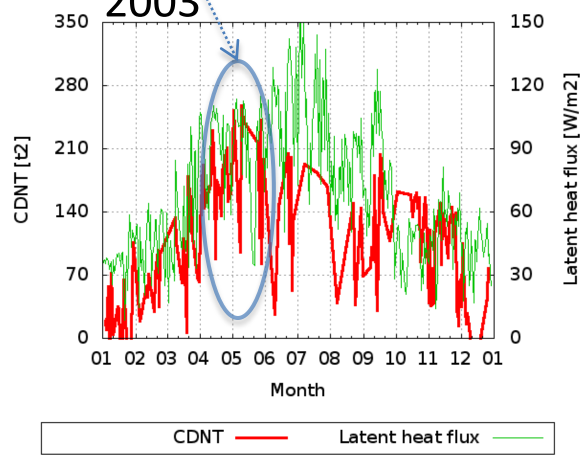


From MOD11C1 (Day/Night LST, 0.05deg.), MOD09CMG (reflectance, 0.05deg.)

2001   Stressed case



2003



CDNT can indicate the Water Stress Trend

Sitename/FLUXNET ID: Donaldson / US-SP3
State/Province: Florida, USA
Sponsor: DOE/NIGEC
Lat, Lon, Elevation: 29.7547, -82.1633, 36m
Vegetation (IGBP): Evergreen needleleaf forest

PI: Moriyama

5. Summary

- ✓ **GCOM-C1/SGLI** has **250m resolution** with 1150~1400km swath, aiming global land, coastal, and aerosol observations (launch in JFY2016 (TBD); 5-year lifetime × 3 satellites = 13 years)
- ✓ SGLI has polarization/ **along-track slant view** of Red and NIR bands; provides the information of the vertical structure of plants; useful for the **land cover** and **above-ground biomass** estimation
- ✓ Day-night **land surface temperature** (250m-500m resolution) observation can be used for estimate of **water stress trend**
- ✓ GCOM-C products will contribute to the emission estimation
  - Land cover → emission types such as fire, dust, VOC..
  - Above-ground biomass → potential emission filed by fire
  - LST & water stress trend → possibility of dust and fire events