Data fusion of MOLI and GCOM-C/SGLI

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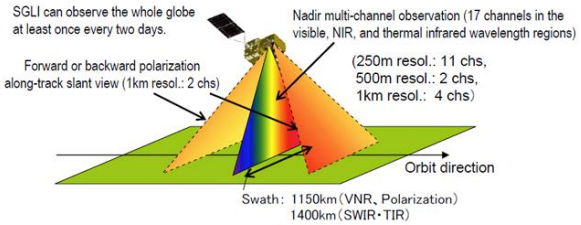
About Global Change Observation Mission - Climate (GCOM-C)

Forecasting future global climate

The purpose of the GCOM (Global Change Observation Mission) project is the global, long-term observation of Earth's environment. GCOM is expected to play an important role in monitoring both global water circulation and climate change, and examining the health of Earth from space. Global and long-term observations (10-15 years) by GCOM will contribute to an understanding of water circulation mechanisms and climate change.
GCOM consists of two satellite series, the GCOM-W and GCOM-C.
The GCOM-C, carrying a SGLI (Second generation GLobal Imager), conducts surface and atmospheric measurements related to the carbon cycle and radiation budget, such as clouds, aerosols, ocean color, vegetation, and snow and ice.
GCOM-C1 is the first satellite is the GCOM-C series.

http://global.jaxa.jp/projects/sat/gcom

SGLI is an optical sensor for monitoring the long-term trends of aerosol-cloud interactions and for understanding the carbon cycle.

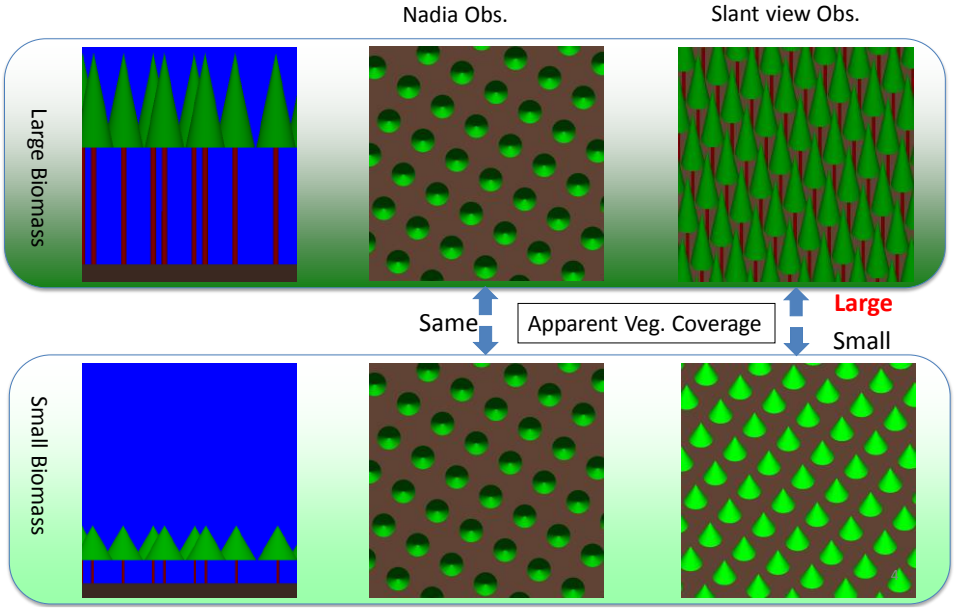


http://suzaku.eorc.jaxa.jp/GCOM_C/w_sgli/obs_sgli.html

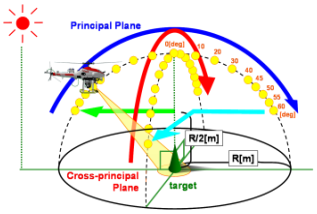
GCOM-C1 / SGLI Land products

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

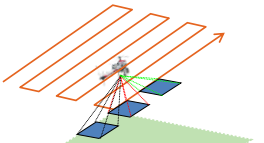
Advantage of Multi-Angle Observation for Biomass Estimation



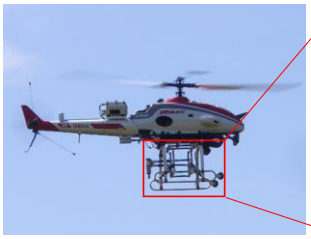
Equipments for BRF measurement

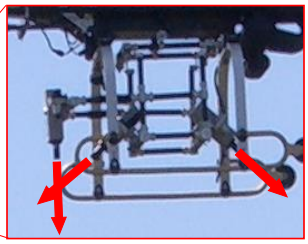


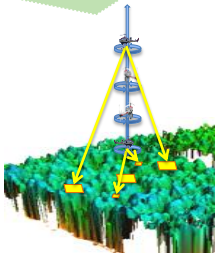
BDRF measurement flight



3 Direction
BDRF measurement flight

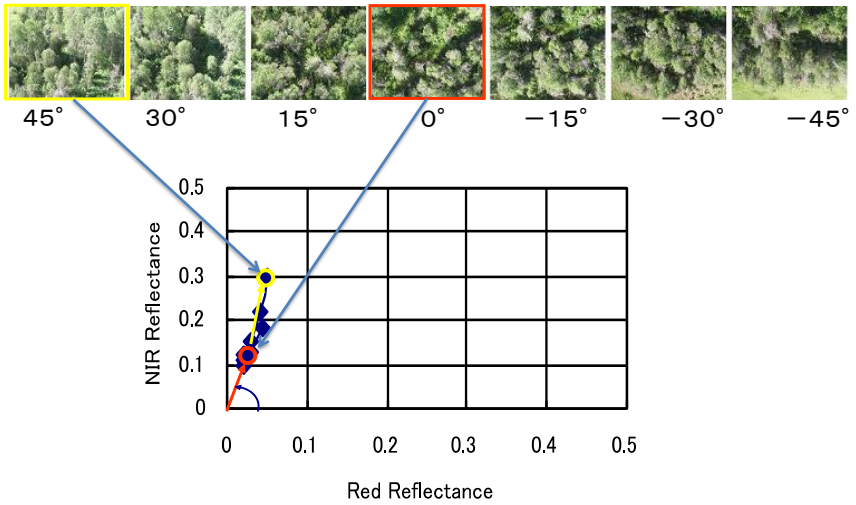




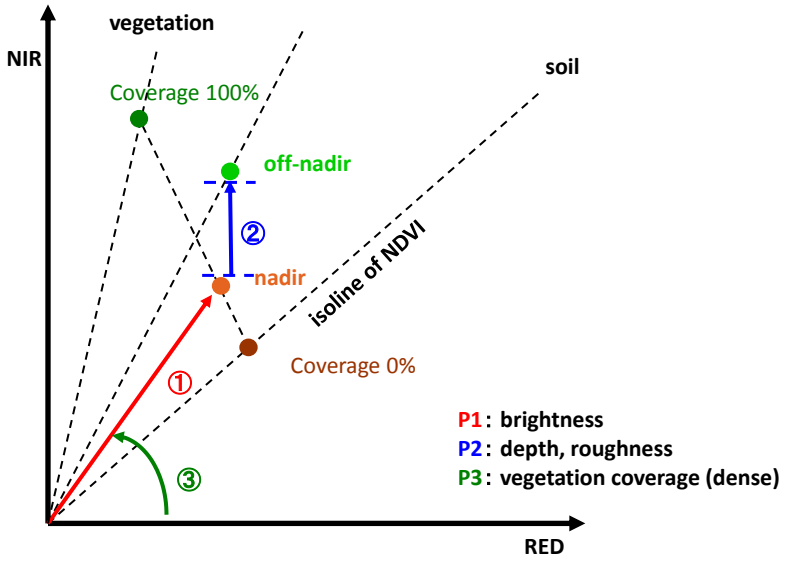


Represent Area
multi-direction flight

Red-NIR Plot of Broadleaf



Reflectance Shift in Red-NIR plane



Biomass Estimation using P1,P2,P3

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

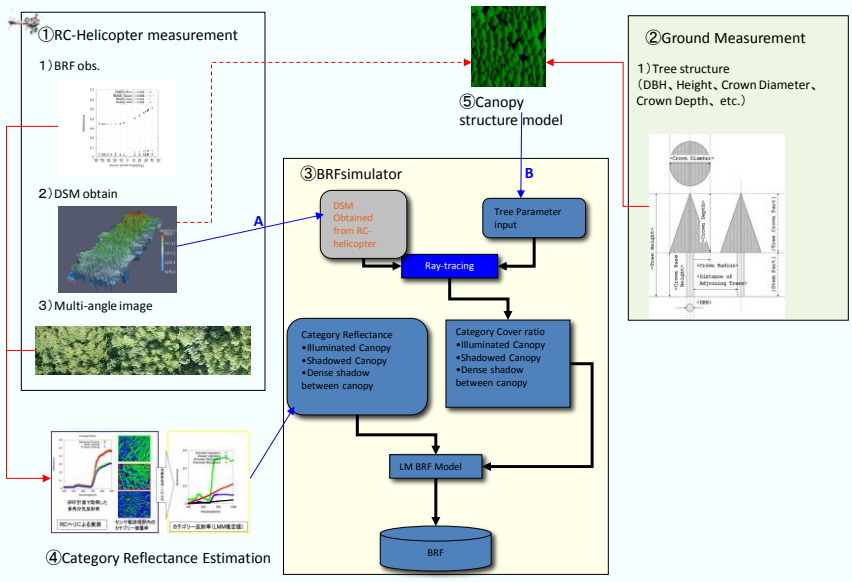
Forest Type Dependent Coefficient

Volume related term

Vegetation Coverage

- P1, P2, P3 should be used the reflectance on fixed Sun-Target-Sensor Geometry (STSG).
- To obtain the P1, P2, P3 at fixed STSG, satellite observed reflectance has to simulate with BRDF model.

BRDF Simulator ; BiRS

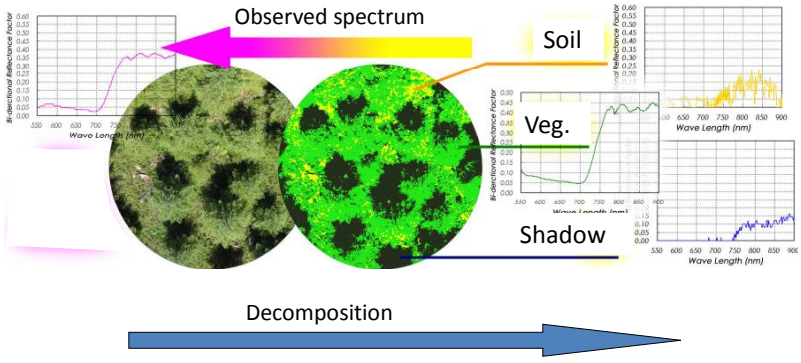


BRDF Liner Mixture Model

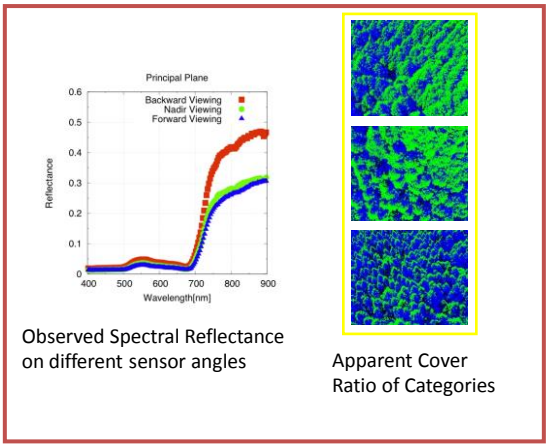
$$BRDF_{\lambda}(\theta_s,\phi_s,\theta_o,\phi_o) = \sum_{i=1}^{n} CR_i(\theta_s,\phi_s,\theta_o,\phi_o) \times RF_{\lambda,i}$$

θ_s : Solar Zenith Angle
ϕ_s : Solar Azimuth Angle
θ_o : *Sensor* Zenith Angle
ϕ_o : *Sensor* Azimuth Angle

CR : Cover Ratio
RF : Reflectance
λ : Wave length
i : Category Number

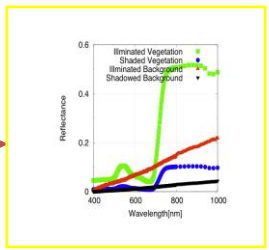


Category Cover Ratio & Spectrum (from Helicopter measurement)



Observed Spectral Reflectance on different sensor angles

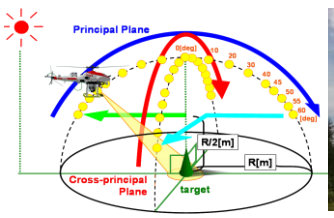
Apparent Cover Ratio of Categories



Spectral Reflectance of each Category

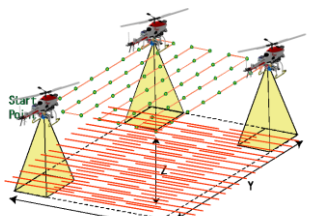
Obtained from Helicopter measurement

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

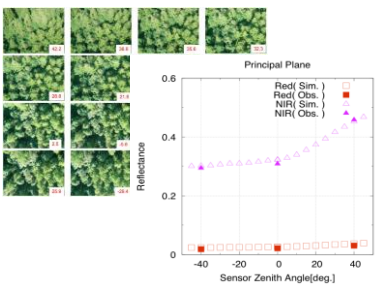


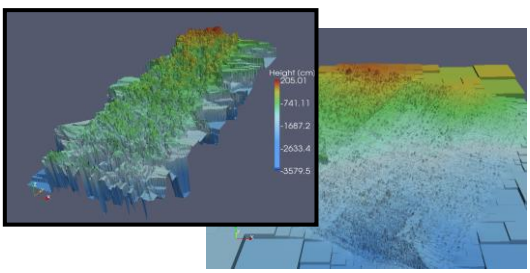
BRF measurement

Unmanned helicopter

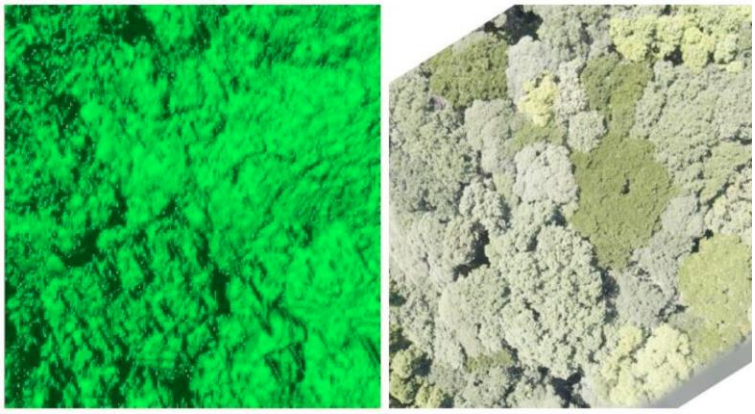


Canopy structure measurement using scanning LIDER

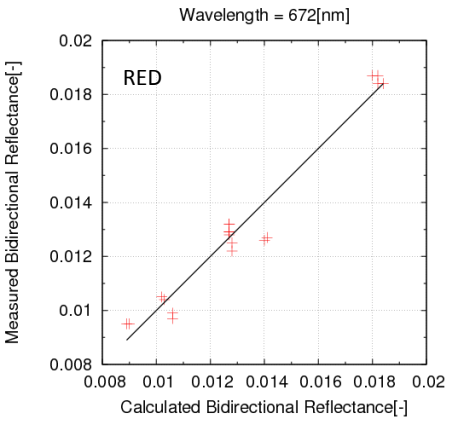




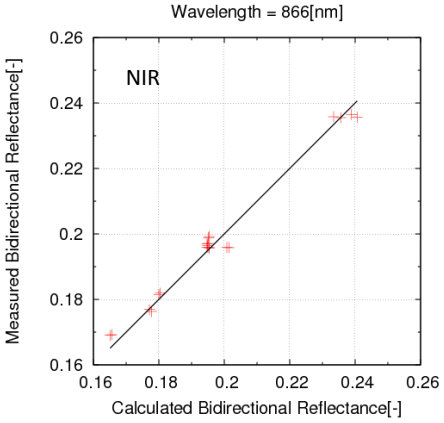
Comparison between DSM shade image & Still image



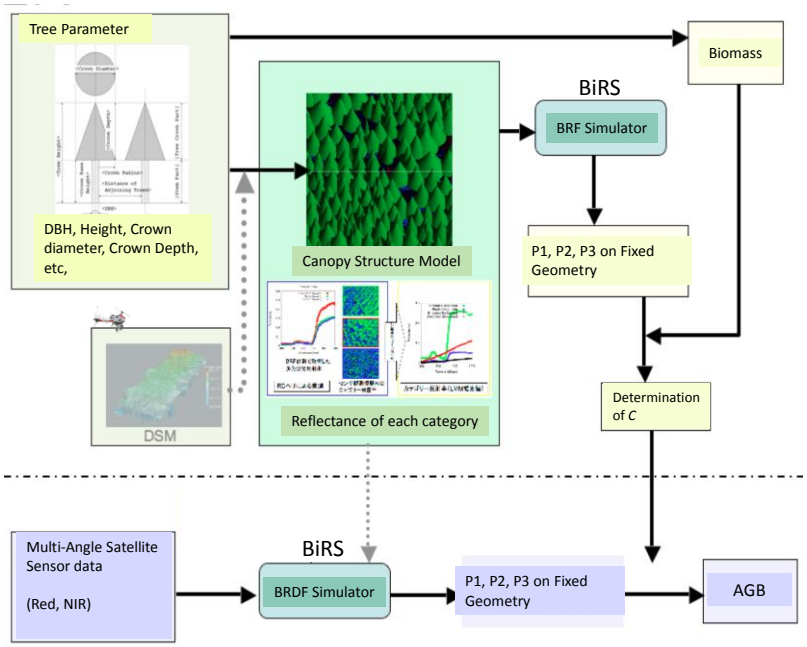
Comparison between Measured and Simulated Reflectance



RMSE = 0.0006

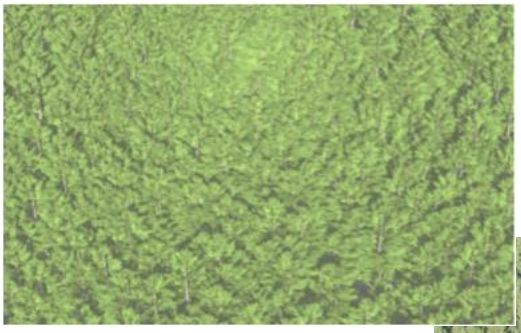


RMSE = 0.0029

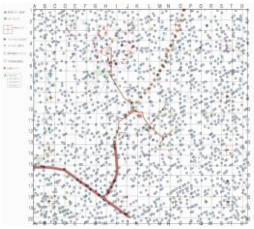


Canopy structure modering

Model output based on ground measured plot data
Fuji-Hokuroku site



Model output

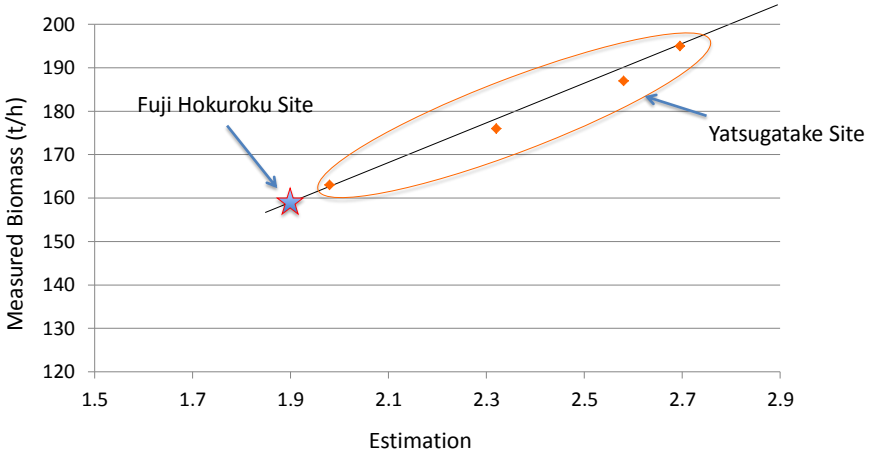


Plot data provided by Prof. T. Okano, Shinshu Univ.

Site map provided by Dr. N. Saigusa, NIES

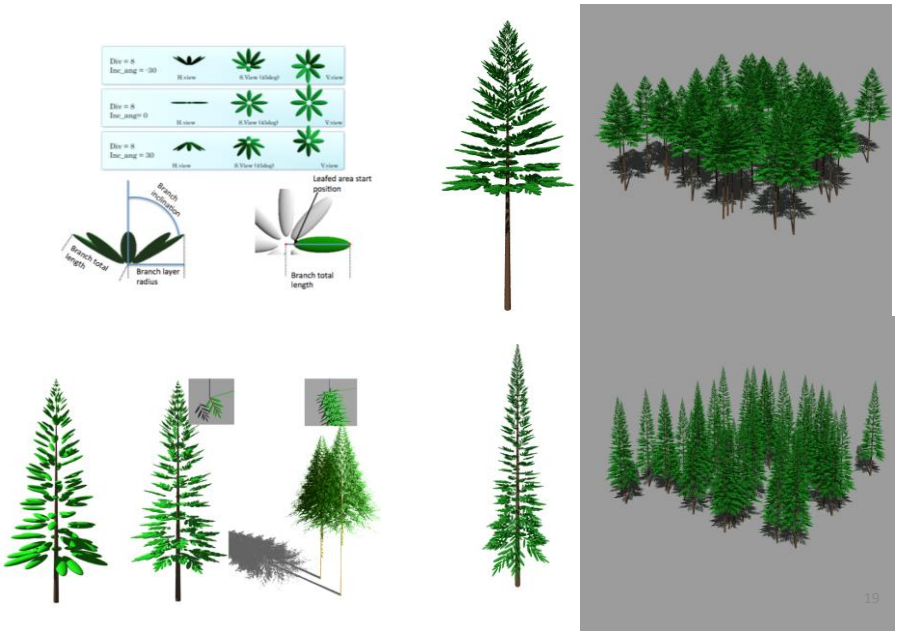
Still image taken from 100m height

Biomass Estimation Result for Larch forest



Y2000 to Y2006
STSG; Solar Zenith=40deg, Sensor Zenith=40deg , Conifer Model
C=75.63

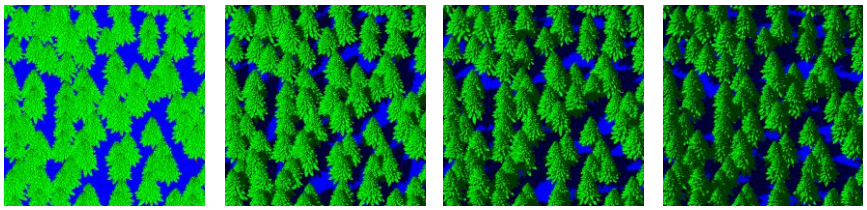
Canopy model used to BIRS simulation



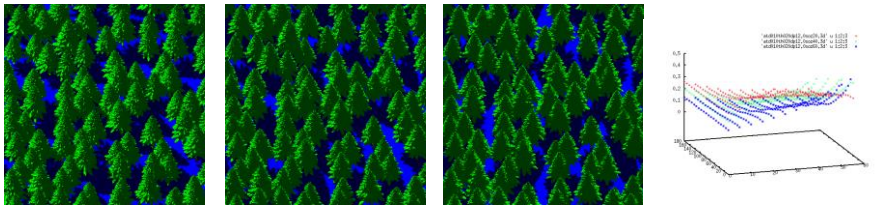
BiRS output category images

Mean Adjacent Tree Distance = 12.55m, Mean Tree Height = 20m, Crown Depth = 12.0m

SOZ= 40deg, SEZ = 40deg



REA = 0 REA = 30 REA = 60 REA = 90

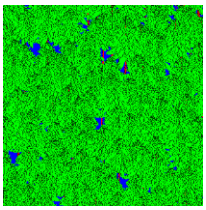


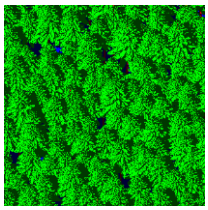
REA = 120 REA = 150 REA = 180

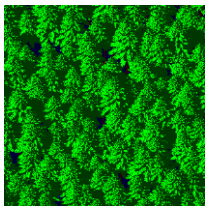
BiRS output category images

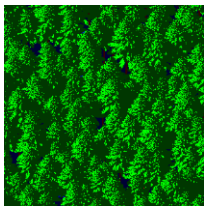
Mean Adjacent Tree Distance = 6.64m, Mean Tree Height = 15m, Crown Depth = 4.5m

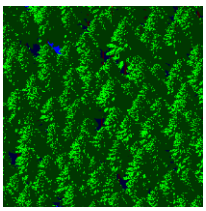
SOZ= 40deg, SEZ = 40deg

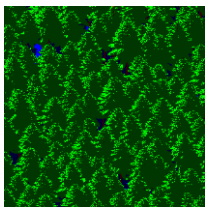

REA = 0

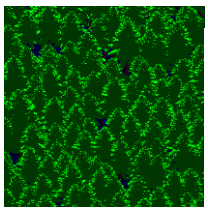

REA = 30

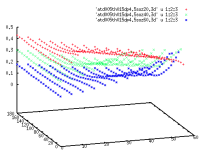

REA = 60


REA = 90


REA = 120


REA = 150

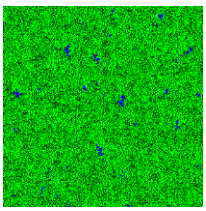

REA = 180



BiRS output category images

Mean Adjacent Tree Distance = 3.87m, Mean Tree Height = 10m, Crown Depth = 5.0m

SOZ= 40deg, SEZ = 40deg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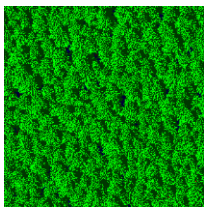
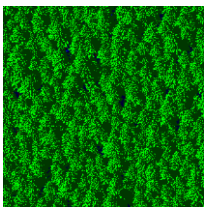
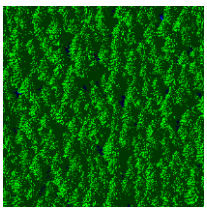
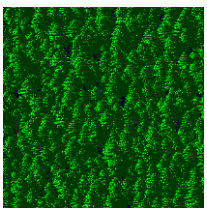
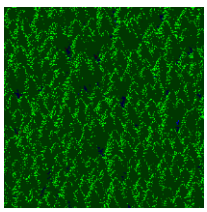
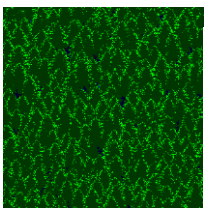

REA = 30

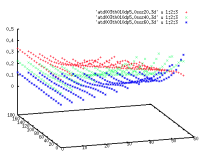

REA = 60


REA = 90


REA = 120

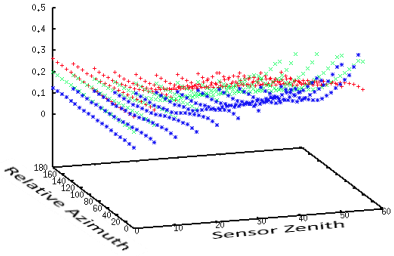

REA = 150


REA = 180

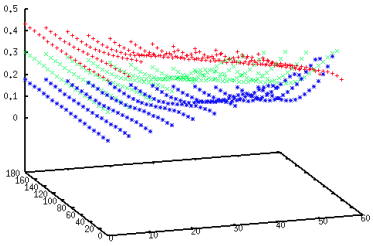


Simulated BRDF using canopy structure model

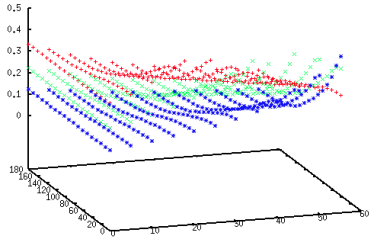
ATD12.55, TH=20m, CD =12.0m



ATD=6.64m, TH=15m, CD=4.5m



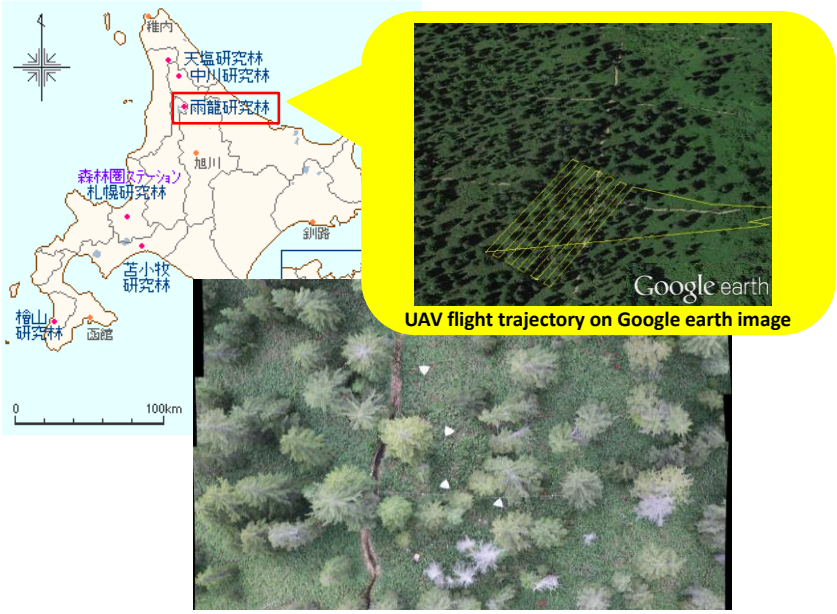
ATD3.87, TH=10m, CD =5.0m



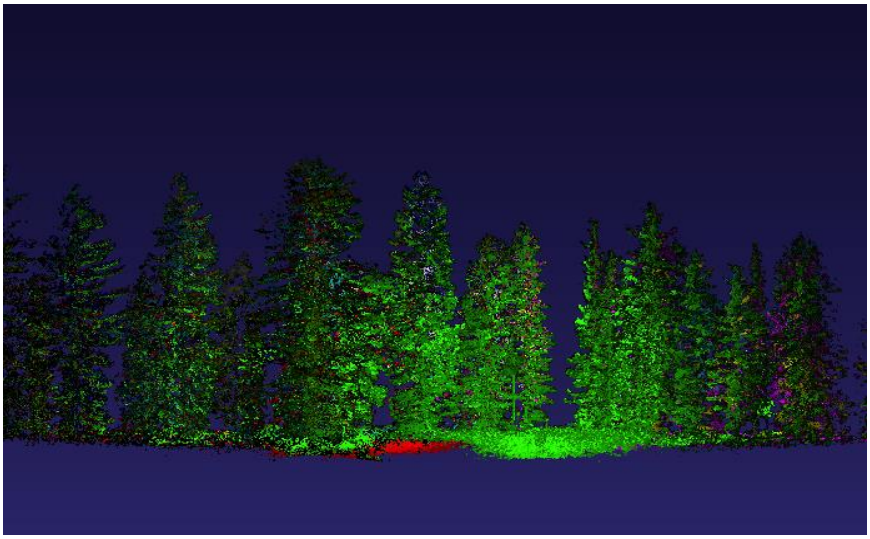
x Solar Zenith Angle = 20
x Solar Zenith Angle = 40
x Solar Zenith Angle = 60

In-situ data collection for BRDF simulation

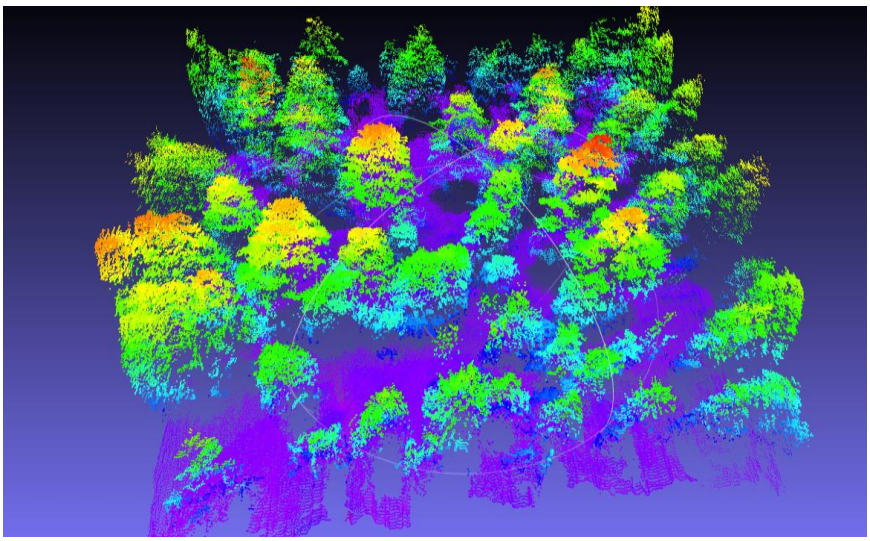
Sakhalin spruce site in “Uryu” Experimental Forest of Hokkaido University



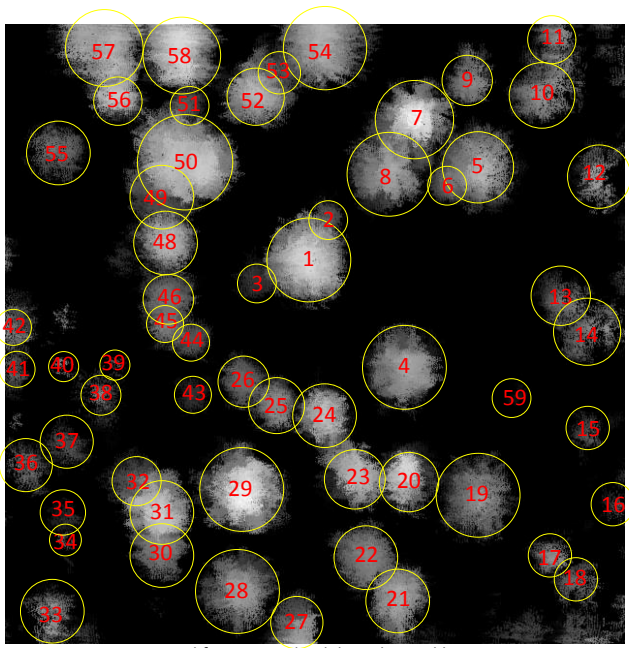
地上レーザー点群データ（6地点合成点群）



ヘリからのレーザー計測



Dorokawa site: Tree height & Crown diameter

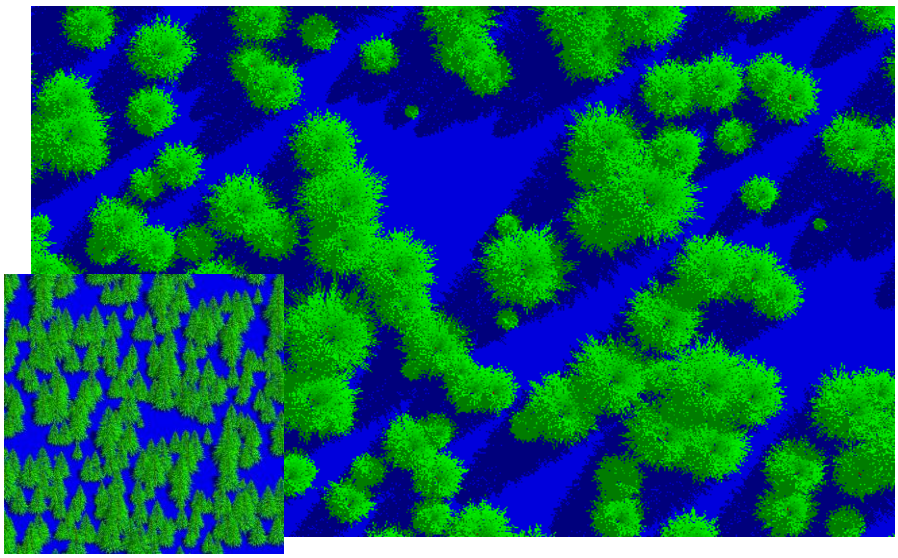


ID	x	y	th	cd
1	329	246	166.69	81.63
2	382	265	48.17	30.27
3	259	266	44.15	30.15
4	228	354	131.81	75.50
5	491	147	144.91	73.54
6	457	166	89.35	27.77
7	423	97	193.24	82.95
8	390	150	134.10	71.70
9	479	63	108.02	43.00
10	557	67	118.40	61.10
11	567	13	112.11	35.73
12	613	164	133.09	51.62
13	581	291	97.18	43.01
14	609	318	109.71	65.10
15	601	421	71.83	34.41
16	632	496	73.50	37.00
17	564	551	111.89	35.00
18	591	576	84.84	52.50
19	487	488	123.12	75.43
20	417	469	164.70	58.00
21	406	589	130.92	62.43
22	372	550	105.98	60.42
23	362	465	145.99	57.58
24	328	403	147.75	53.25
25	280	393	110.30	49.65
26	245	368	84.64	45.04
27	301	620	127.97	56.00
28	240	585	125.14	82.04
29	245	483	189.11	86.05
30	162	544	113.76	50.99
31	160	502	159.44	65.00
32	135	477	83.50	48.80
33	46	609	120.97	60.28
34	59	531	96.62	19.70
35	61	510	42.43	37.64
36	24	458	90.40	55.15
37	63	434	67.15	43.86
38	98	383	110.36	45.45
39	114	352	72.19	17.49
40	56	351	101.12	20.02
41	3	358	77.54	30.00
42	4	132	107.65	40.01
43	193	381	42.24	26.17
44	193	325	71.91	26.08
45	171	310	101.44	33.24
46	168	283	91.49	51.62
47	121	242	67.07	21.00
48	145	200	144.59	60.00
49	161	172	69.51	76.97
50	188	139	154.85	101.18
51	187	85	72.93	32.28
52	261	75	141.78	69.12
53	291	48	66.34	37.05
54	325	21	138.36	84.84
55	54	130	92.16	51.88
56	114	76	154.09	49.82
57	97	20	143.41	75.85
58	178	26	169.55	73.56
59	528	382	26.46	13.33

Unit : cm

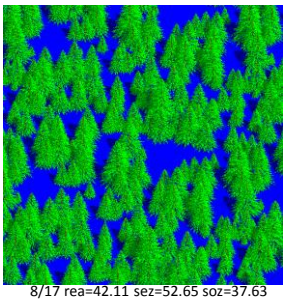
Image created from Point cloud data obtained by UAV

Canopy model for BRDF simulation

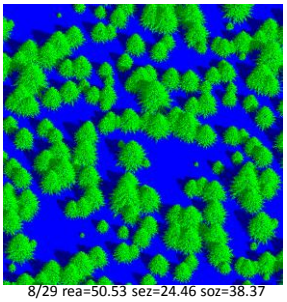


Output Category images of BiRS

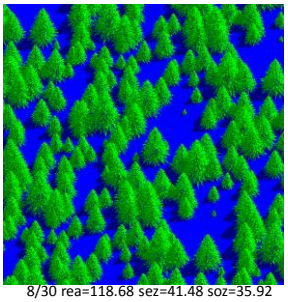
Corresponds Sun-Target-Sensor geometry of MODIS observation



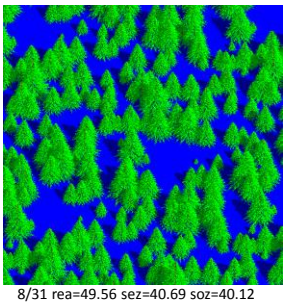
8/17 rea=42.11 sez=52.65 soz=37.63



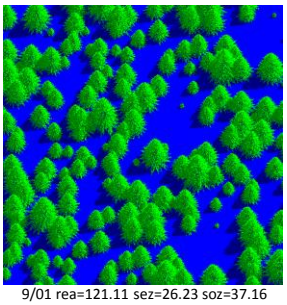
8/29 rea=50.53 sez=24.46 soz=38.37



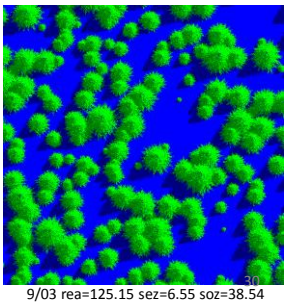
8/30 rea=118.68 sez=41.48 soz=35.92



8/31 rea=49.56 sez=40.69 soz=40.12



9/01 rea=121.11 sez=26.23 soz=37.16

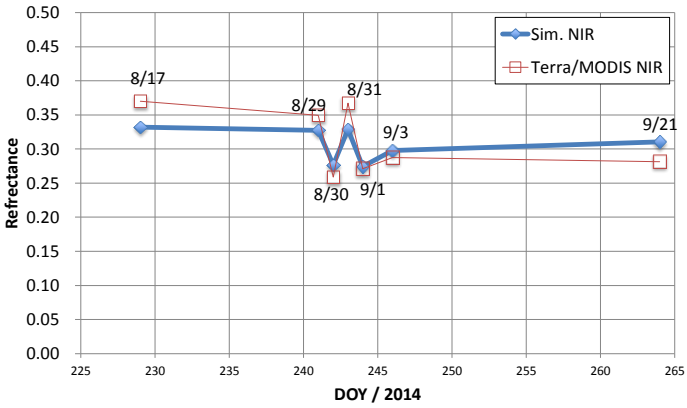


9/03 rea=125.15 sez=6.55 soz=38.54

Comparison between simulation results of and in-situ data
(Compare to Terra/MODIS NIR refl.)

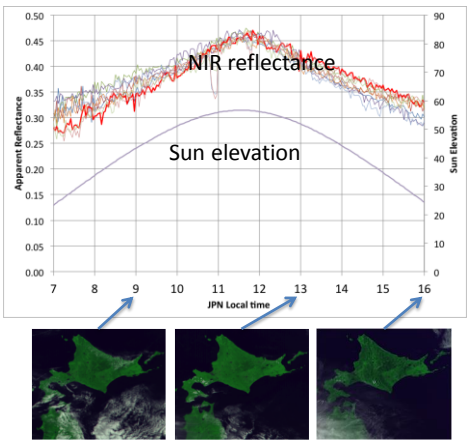
MODIS Observation status

Date	DOY	SOZ	REA	SEZ	Aflg
8/17	229	37.63	42.11	52.65	A2
8/29	241	38.37	50.53	24.46	A1
8/30	242	35.92	118.68	41.48	A1
8/31	243	40.12	49.56	40.69	A1
9/01	244	37.16	121.11	26.23	A1
9/03	246	38.54	125.15	6.55	A1
9/21	264	45.54	59.02	14.87	A1



High temporal resolution data of AHI/HIMAWARI-8 is a promising candidate for the BRDF verification

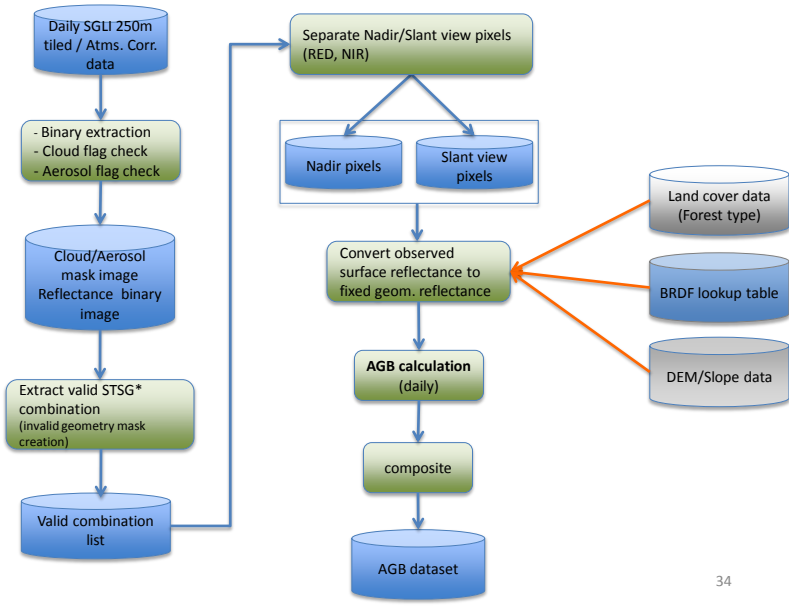
Apparent reflectance of AHI/HIMAWARI-8



R:G:B=RED:NIR:BLUE

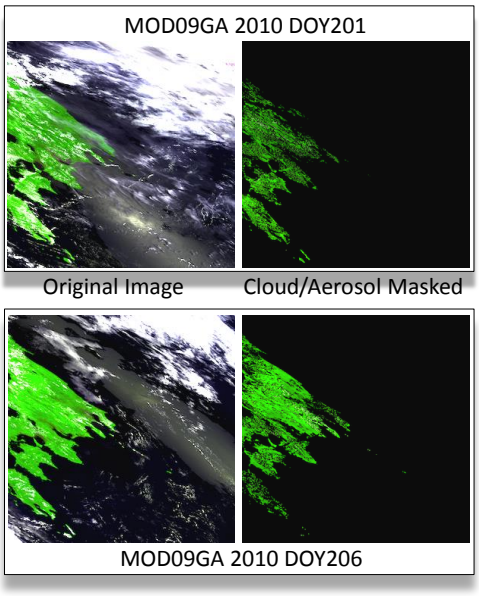
Apply to Satellite data (…MODIS)

Process flow of AGB (for MODIS data)



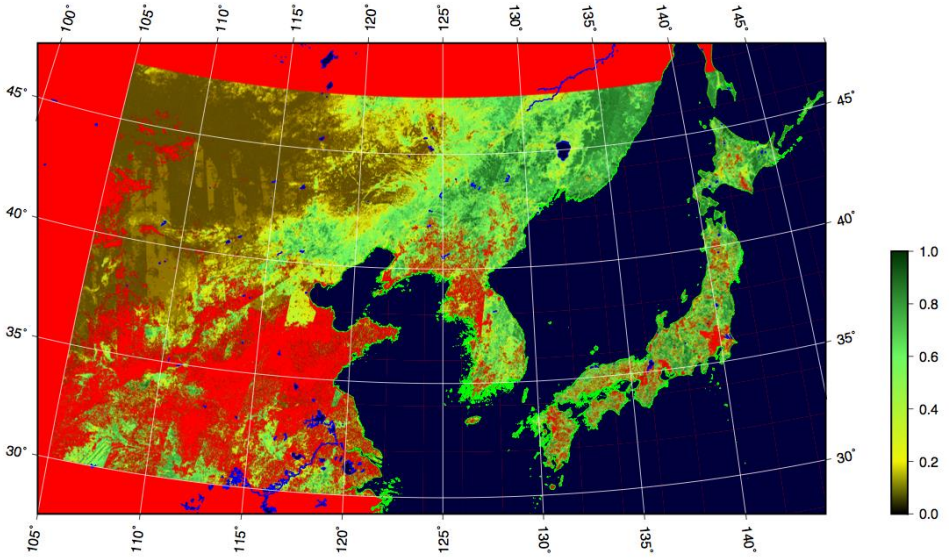
STSG* :
Sun-Target-Sensor Geometry

Nadir / Slant view pair pixels selection (for MODIS)



$0 < SEZ_{Nadir} < 15$ && $SEZ_{Nadir} + 30 < SEZ_{slant}$

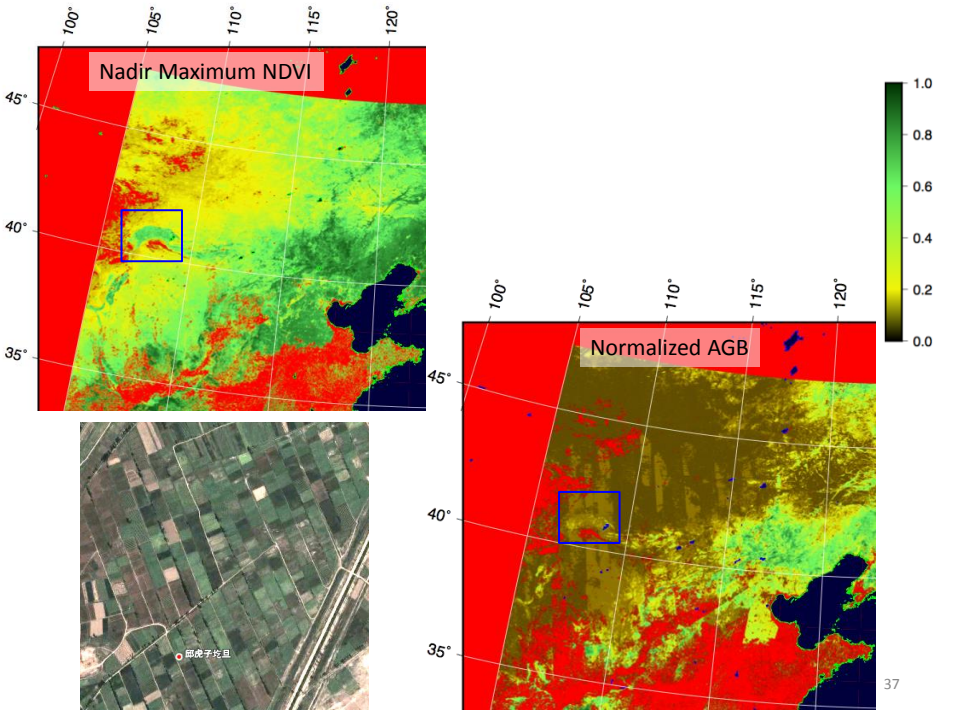
Processing result for 2010 summer on East Asia (AGB)

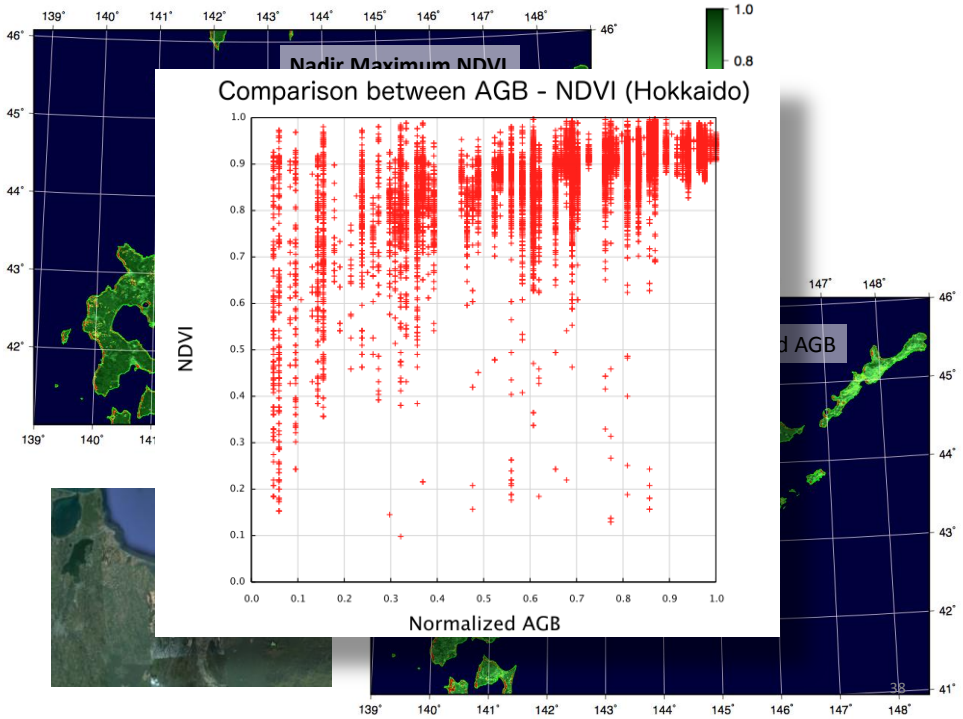


Red color indicates invalid STSG/reflectance combination found or nadir NDVI < 0 pixel

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

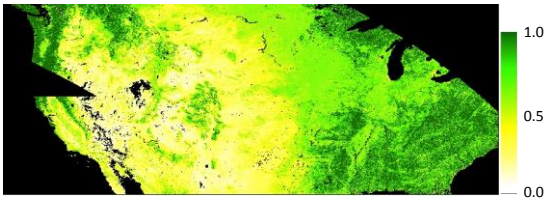
8 tiles: h25v04, h26v04, h26v05, h27v04, h27v05, h28v04, h28v05, h29v05


Nadir Maximum NDVI
Normalized AGB
100°
105°
110°
115°
120°
45°
40°
35°
1.0
0.8
0.6
0.4
0.2
0.0

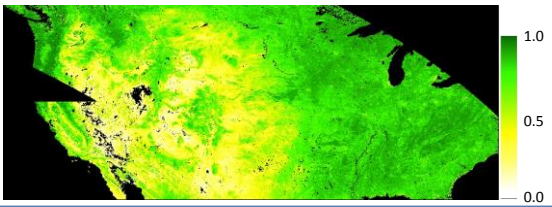

Comparison between AGB - NDVI (Hokkaido)
NDVI
Normalized AGB
139°
140°
141°
142°
143°
144°
145°
146°
147°
148°
46°
45°
44°
43°
42°
41°
1.0
0.8

Processing result of North America on 2012 summer

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



AGB

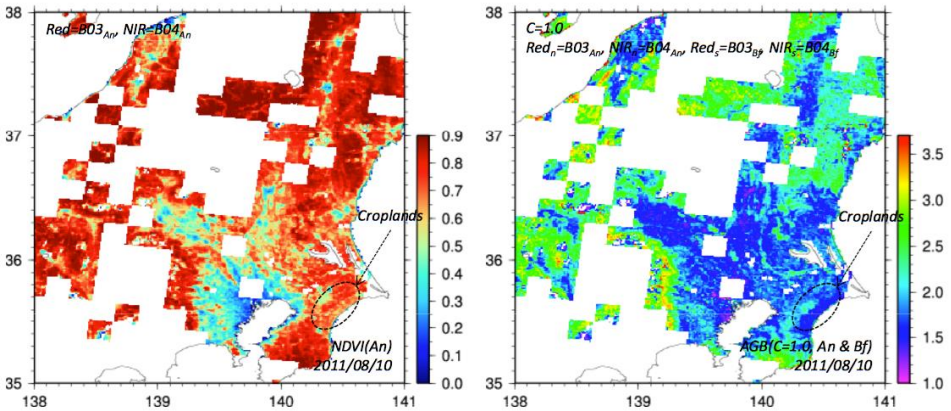


NDVI

Forest/Non-Forest map 2010
from ALOS/PALSAR
(JAXA/EORC)

http://www.eorc.jaxa.jp/ALOS/guide/jforestmap_oct2010.htm

Processing result using MISR data

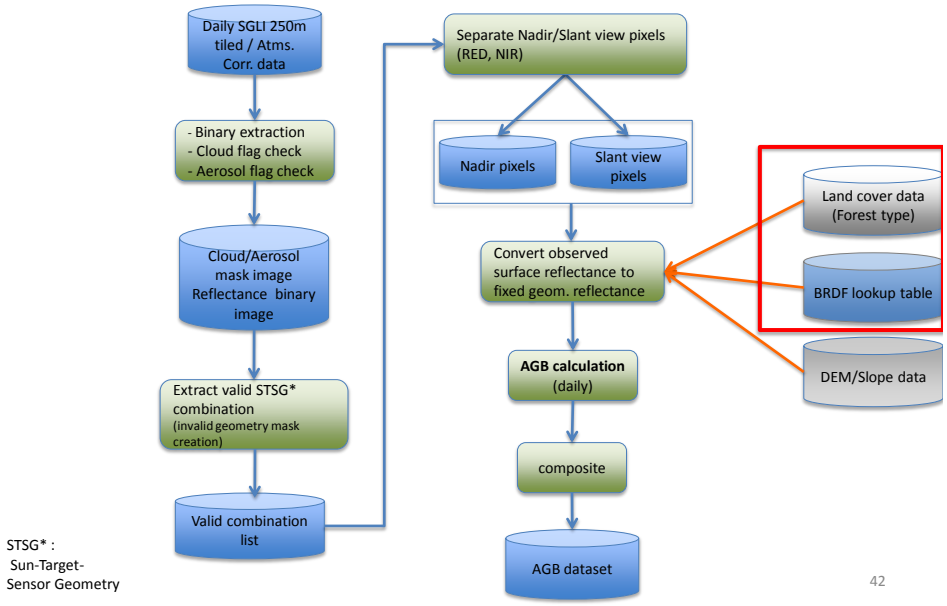


Summary of AGB estimation for SGLI

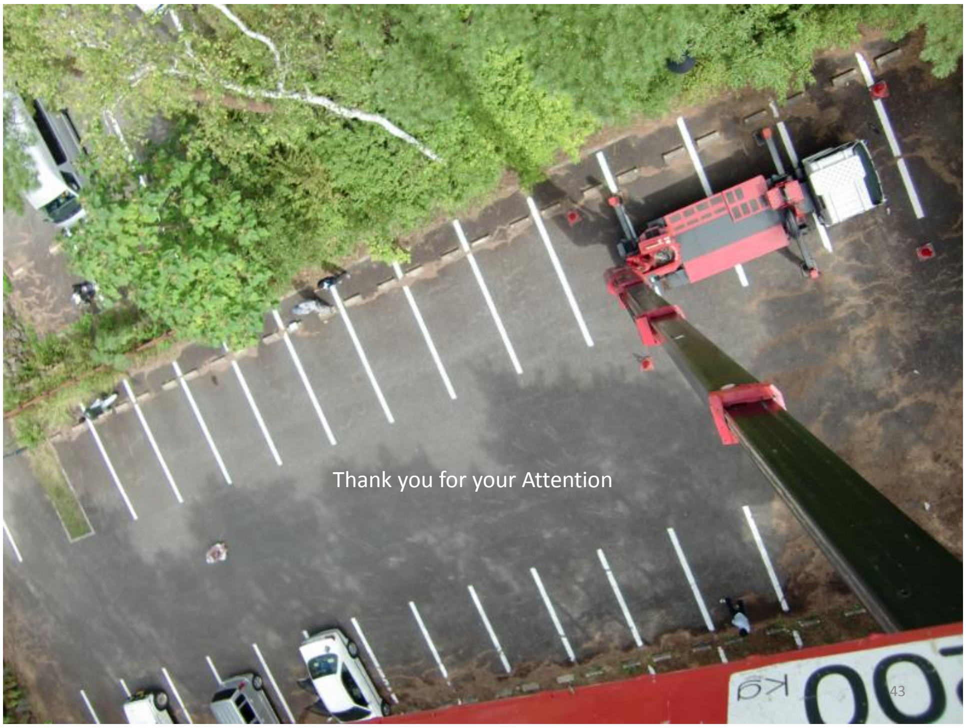
- AGB estimation algorithm uses simulated reflectance using SGLI observed nadir/slant reflectance.
- BRDF simulation results meets well for in-situ forest structure measurement.
- Preliminary results of AGB estimation using MODIS, MISR data has no contradiction qualitatively.

- …but
  - Forest type dependent constant 'C' should be decided by in-situ data collection, allometry equation, or literture search.
  - In order to create BRDF lookup table for tipical forest types, forest structure information such as tree height, crown depth, crown diameter etc.

MOLI provides forest structure information. and it makes AGB estimation accuracy improve



STSG* : Sun-Target-Sensor Geometry


Thank you for your Attention
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