Active fire detection algorithm development

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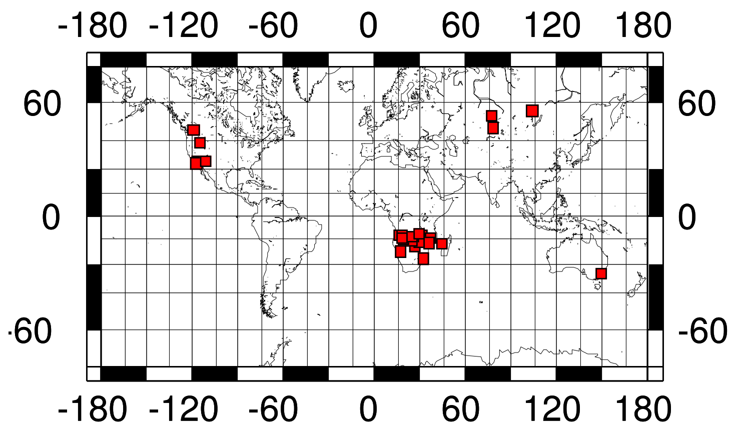
14 Jan. 2014

Whats we made (last RA)

1. Active fire detection algorithm framework with the false alarm rejection criteria (based on 26 ASTER fire scene).
2. Fire temperature and area proportion estimation algorithm.
3. Validation using MODIS dataset.

Fire Detection scheme



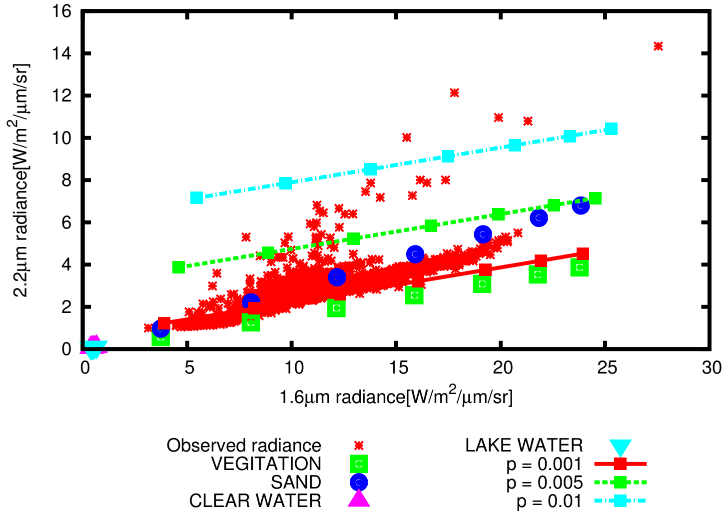
ASTER fire scene (26)

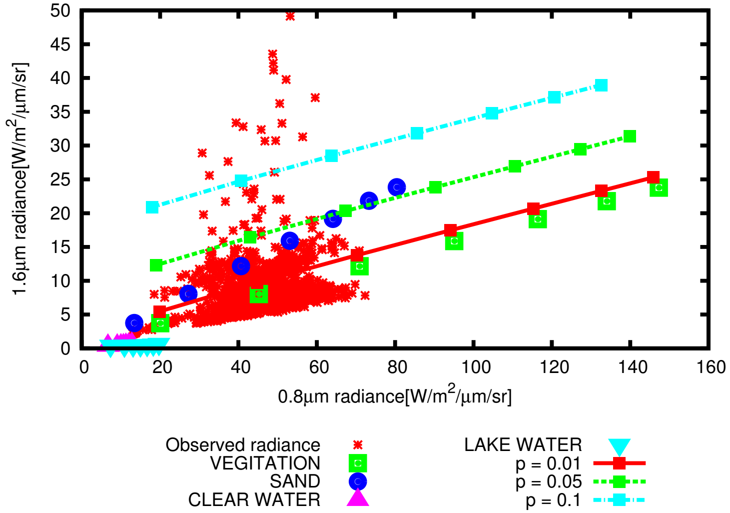
Used channels

SGLI	ASTER	λ	res.
VN11	2	0.8μm	250 m
SW3	4	1.6μm	250 m
SW4	7	2.2μm	1000 m
T1	13	10.8μm	500 m

⇓

- Numerical simulation of the non–fire radiance and comparison between ac tual fire radiance





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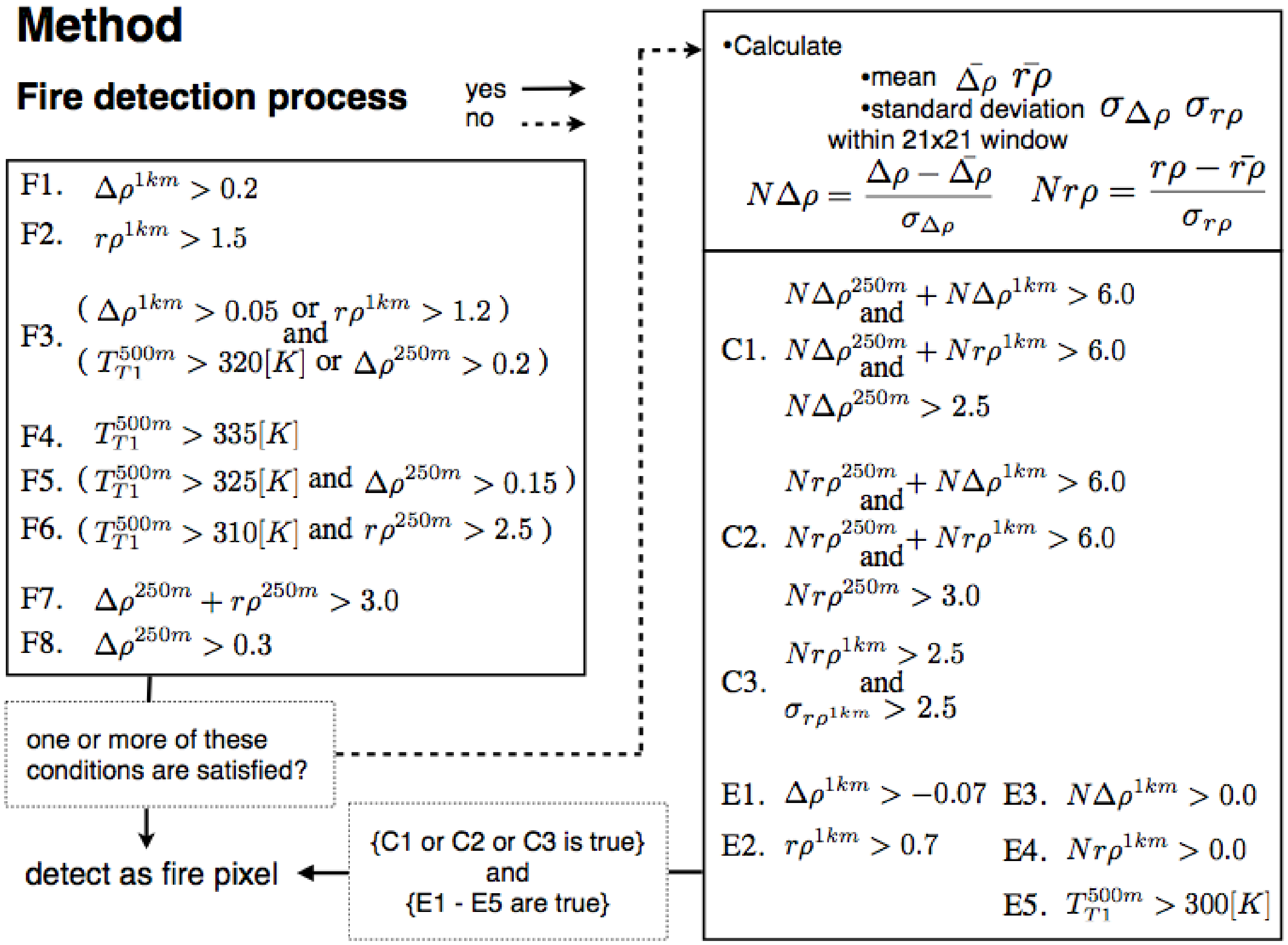
over 0.5% area proportion fire can be detectable

Fire Detection scheme

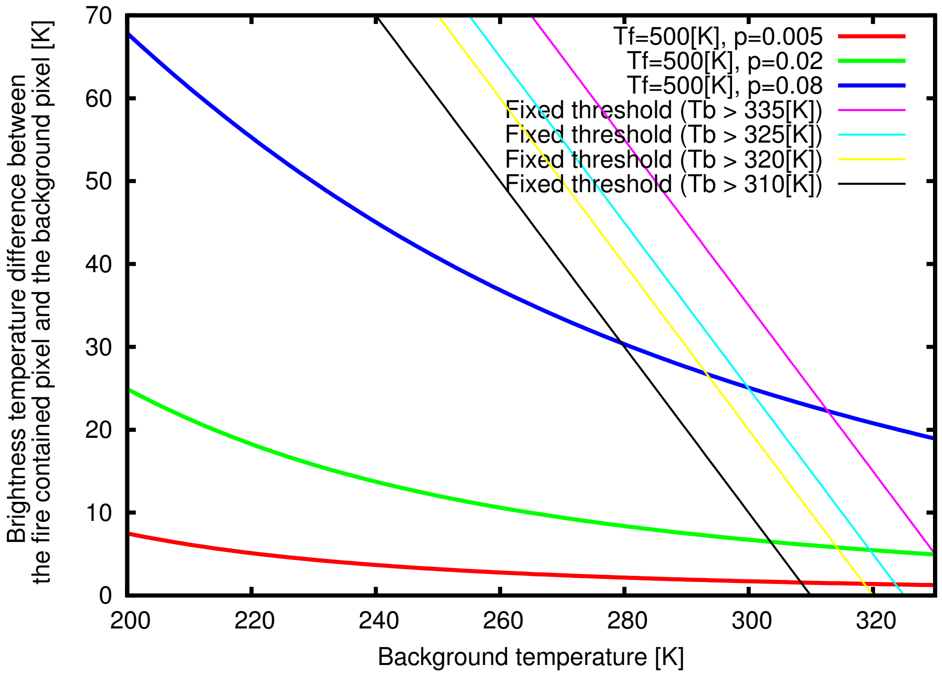


$$\Delta\rho^{250m} = \rho_{SW3}^{250m} - \rho_{VN11}^{250m},\ \Delta\rho^{1km} = \rho_{SW4}^{1km} - \rho_{SW3}^{1km},\ r\rho^{250m} = \frac{\rho_{SW3}^{250m}}{\rho_{VN11}^{250m}},\ r\rho^{1km} = \frac{\rho_{SW4}^{1km}}{\rho_{SW3}^{1km}}$$

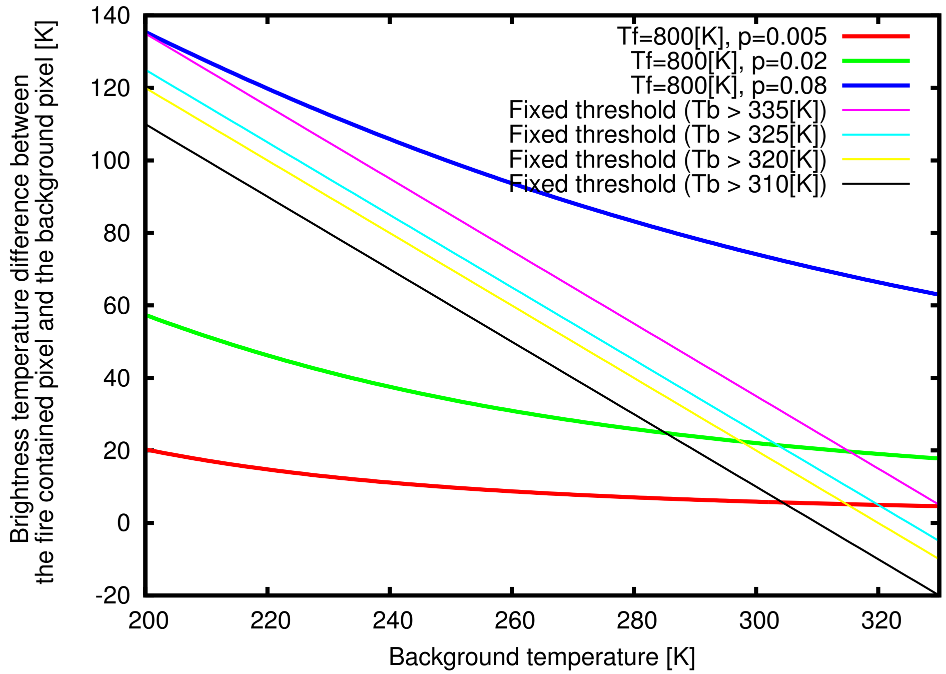
FY2013: TIR channel utilization

SGLI 500/250[m] resolution: Effective?

Brightness temperature difference between the fire contained pixel and the background ← resolution



Smolding case



Framing case

250[m] resolution of TIR is necessary.

Backlog for FY2013

1. Refinement of the contextual test criteria using TIR channel.

2. Gathering LANDSAT 8 fire scene (so far 6 scenes).

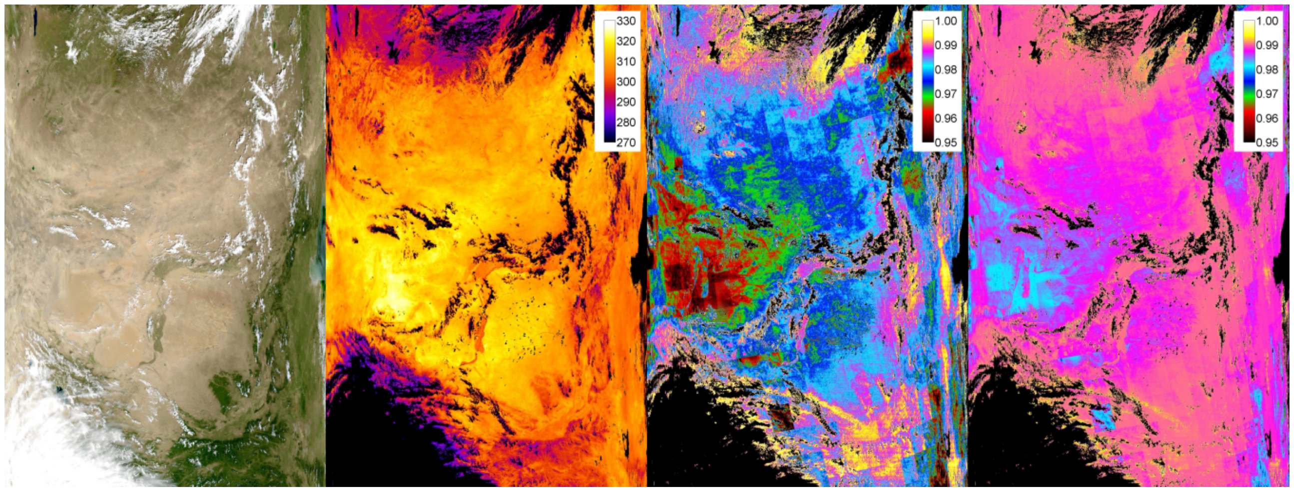
Land surface temperature estimation algorithm development

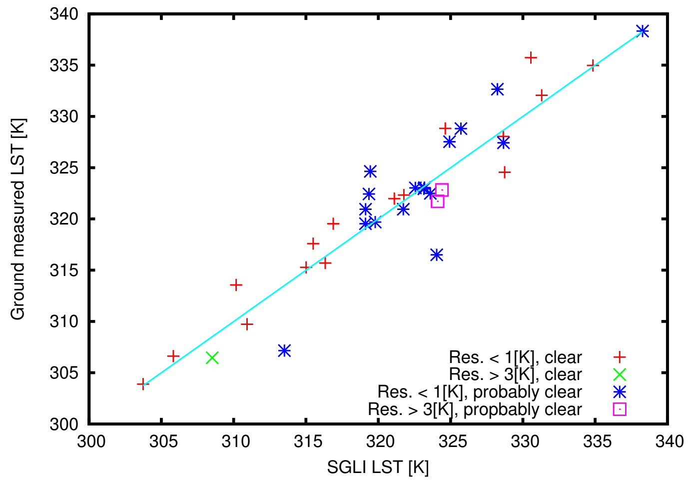
PI: Masao MORIYAMA (Nagasaki Univ., PI#: 104)
CI: Satoshi Tanigawa (Chiba Univ.)

14 Jan. 2014

Whats we made (last RA)

1. The split window algorithm for LST estimation which contains the spectral emissivity explicitly.
2. The semi–analytical LST estimation algorithm which uses the split window algorithm as the constraint.
3. The MODIS based implementation for swath(NU) and global(JAXA) dataset.

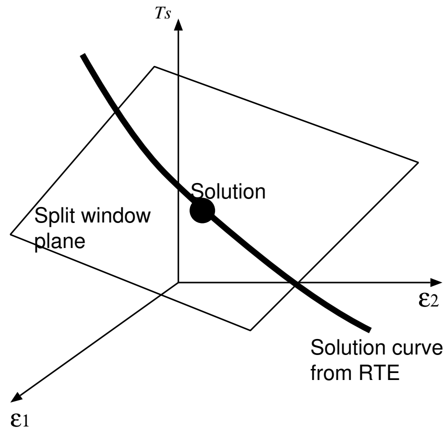




2000/09/15 04:00Z China

@RRV, NV

Semi–analytical LST estimation algorithm



Inputs: Observed brightness temperature T_1, T_2, Atmospheric profile for the computation of τ, I_a, F
Unknowns: $\varepsilon_1, \varepsilon_2, T_s$

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

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

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

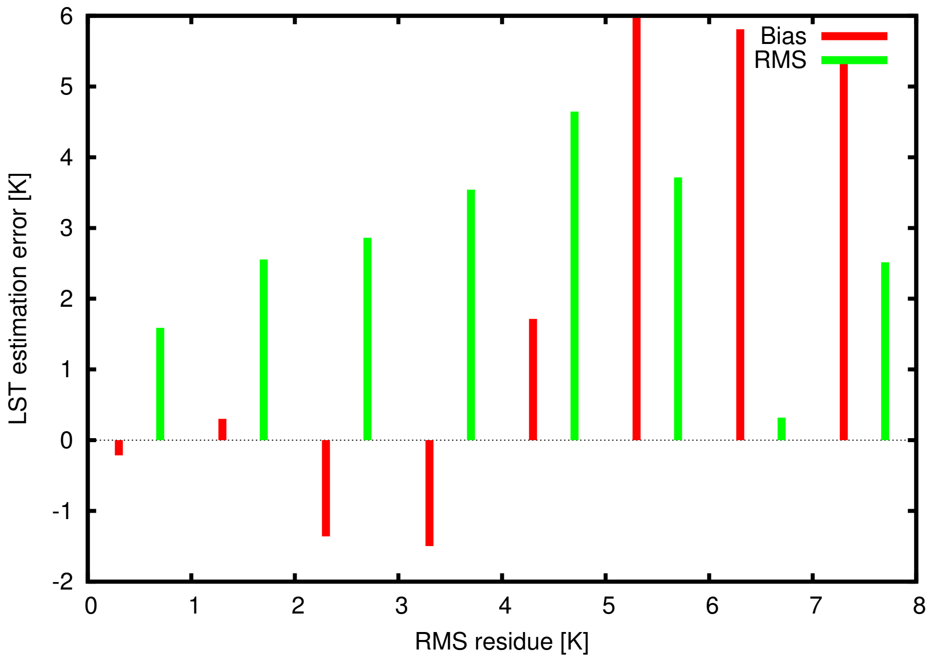
Split window formula is used as the loose constraint for the radiative transfer equation.

$\Downarrow$

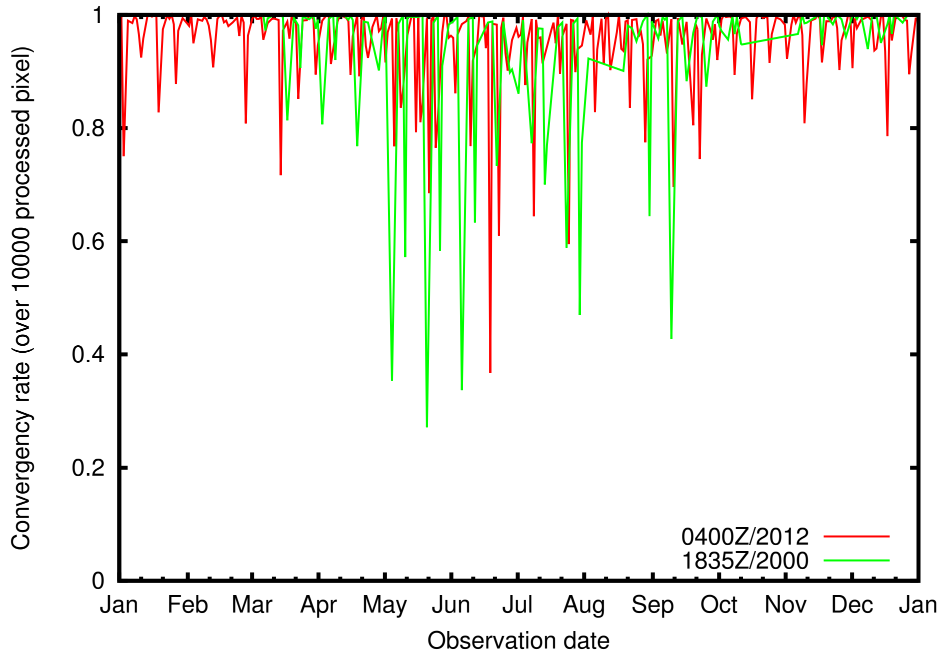
Split window must reflect the actual situation.

FY2013: Proper definition of the split window coefficients

Present status: Single coefficient set from 2000 ECMWF Monthly mean profile and LST and LSE from MODIS Day/Night product.



Relationship between T_s error and the residue



Convergion rate of the MODIS swath data processing

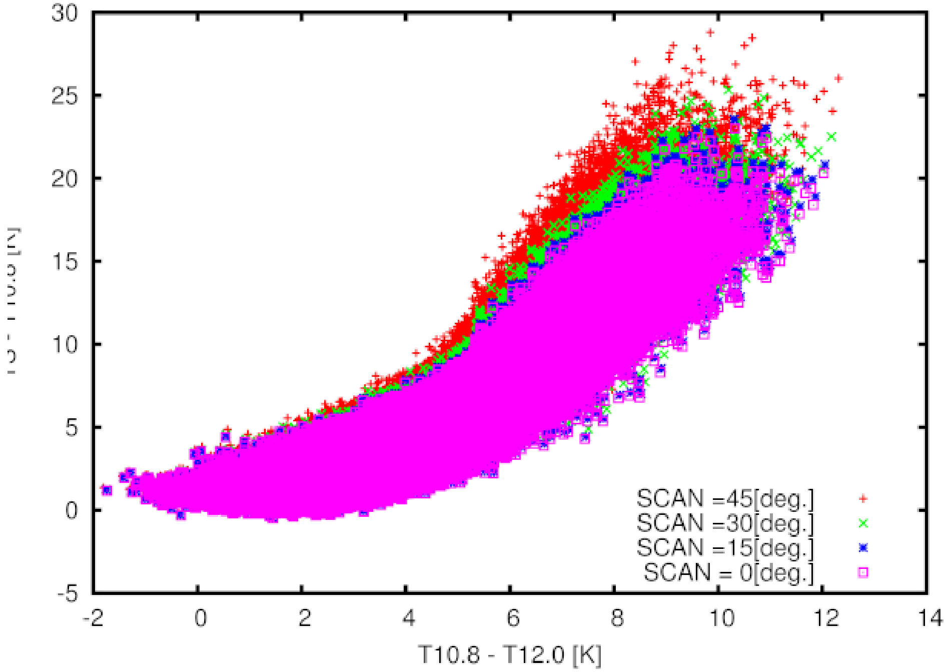
Converge: RMS residue of the cost function is less than 2[K].

Redefinition of the split window coefficients

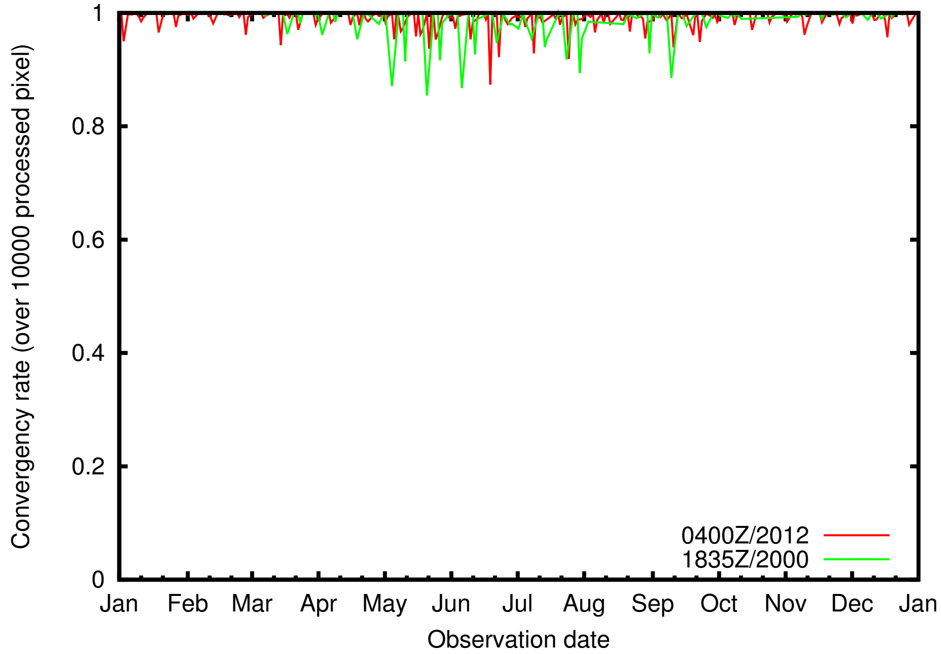
Multiple coefficient sets to reduce the unconverged pixel.

Selection key: brightness temperature, scan angle.

3 sets: $(T_1 - T_2 < 4[\mathrm{K}])$, $(T_1 - T_2 \geq 4[\mathrm{K}]$ and scan $\leq 30[\mathrm{deg.}])$ $(T_1 - T_2 \geq 4[\mathrm{K}]$ and scan $> 30[\mathrm{deg.}])$



Split plane of the numerically computed dataset



Convergion rate of the MODIS swath data processing

Backlog for FY2013

1. Refinement of the split window coefficient sets and the validation using MODIS swath data and Day/Night LST product.

2. Rapid RTC development.

3. Preparation for the code generation(JMA profile use).

4. Field measurement for LANDSAT8 as well as MODIS.

Shadow Index algorithm development

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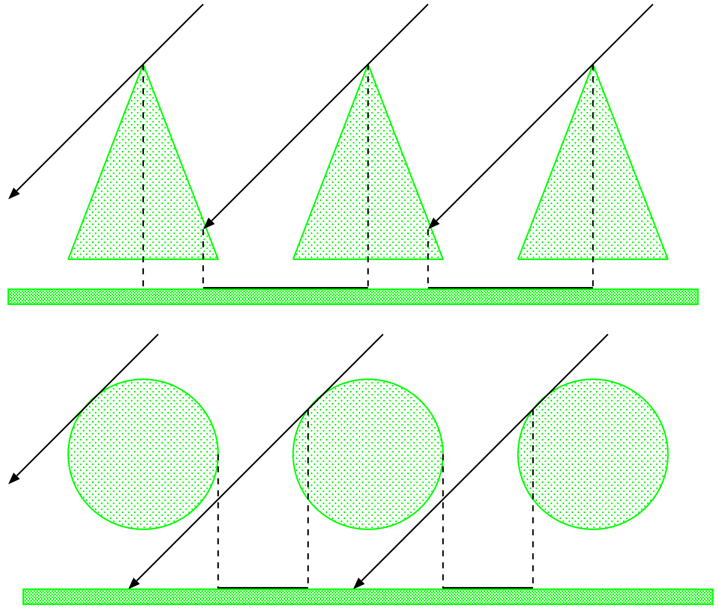
CIs: Yoshiaki HONDA, Koji KAJIWARA (Chiba Univ.),
Akiko ONO (Nara Womens' Univ.)

14 Jan. 2014

Background



Shadow ← No direct solar radiation area

- Cast shadow
- Terrain shadow

↑

3D structure of the surface

Vegetation and shadow

- Even the same vegetation cover, the shadow area proportion is affected by the canopy shape and existence.

Shadow Index: SI → The area proportion of the shadow within a pixel.

Definition of SI

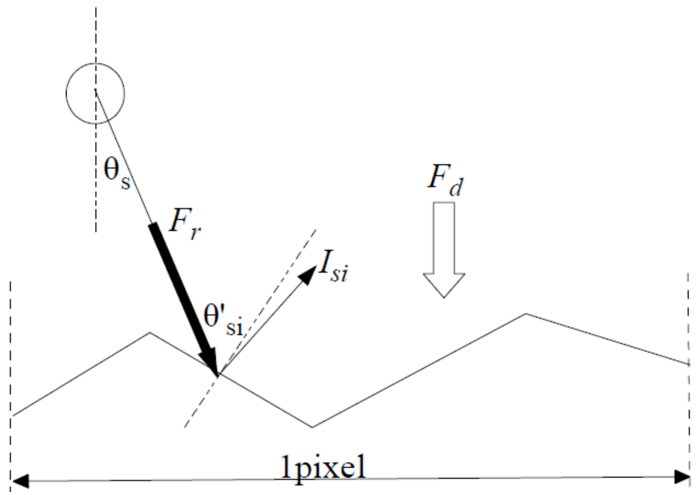
Land leaving radiance from a pixel

$I_s = (F_r \cos(\theta'_s) + F_d)\frac{\rho}{\pi}$, (if $\theta'_s > \pi/2, \cos(\theta'_s) = 0$)

F_r: direct solar irradiance, θ'_s: average incident angle, F_d: diffuse solar irradiance, ρ: average surface reflectance ← Direct reflection contains the shadow

Reflectance scale up

$I_s = \sum[w_i(F_r \cos(\theta'_{si}) + F_d)\frac{\rho_i}{\pi}] = (F_r \cos(\theta'_s) + F_d)\frac{\rho}{\pi}$,
(w_i: area proportion of the ith subsurface)



Assumptions

1. Each subsurface within a pixel has the same reflectance ρ_i and incident angle θ'_{si}.
2. F_r and F_d is constant over a pixel.
3. $\sum[w_i F_r \cos(\theta'_{si})\frac{\rho_i}{\pi}] = F_r \cos(\theta'_s)\frac{\rho}{\pi}$, $\sum[w_i F_d \frac{\rho_i}{\pi}] = F_d \frac{\rho}{\pi}$

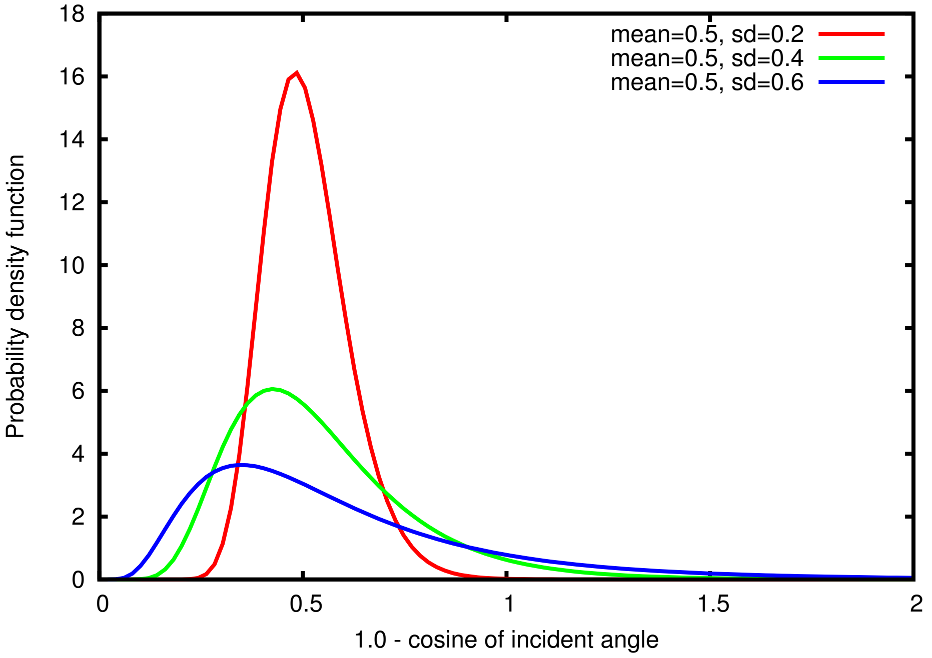
Definition of the average surface reflectance: $\rho = \sum w_i \rho_i$

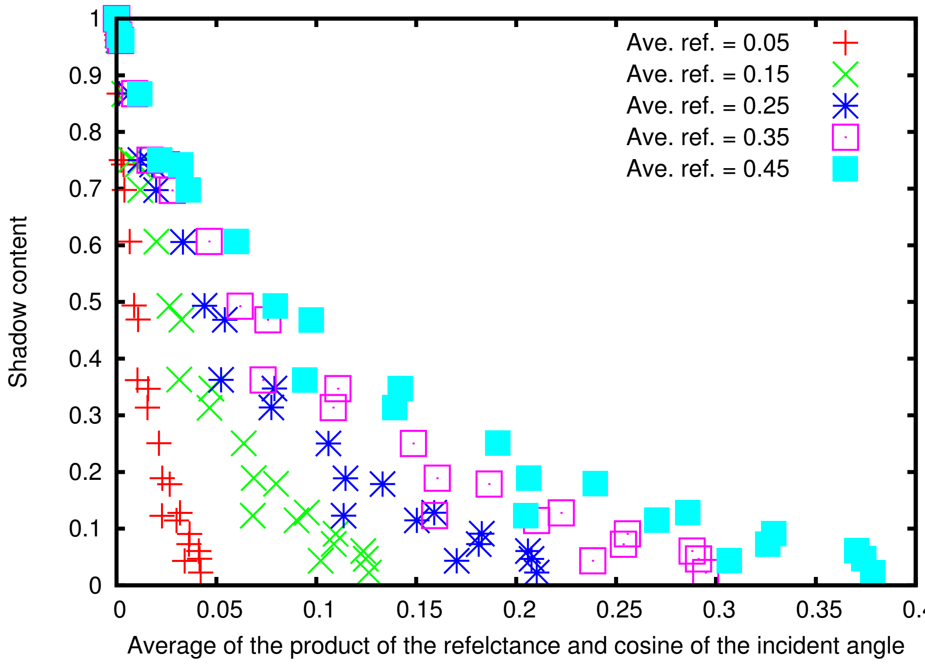
Definition of the average incident angle: $\cos(\theta'_s)\rho = \sum w_i \cos(\theta'_{si})\rho_i$

Definition of SI (*contd.*)

Relationship between the shadow content and $\sum w_i \cos(\theta'_{si})\rho_i$

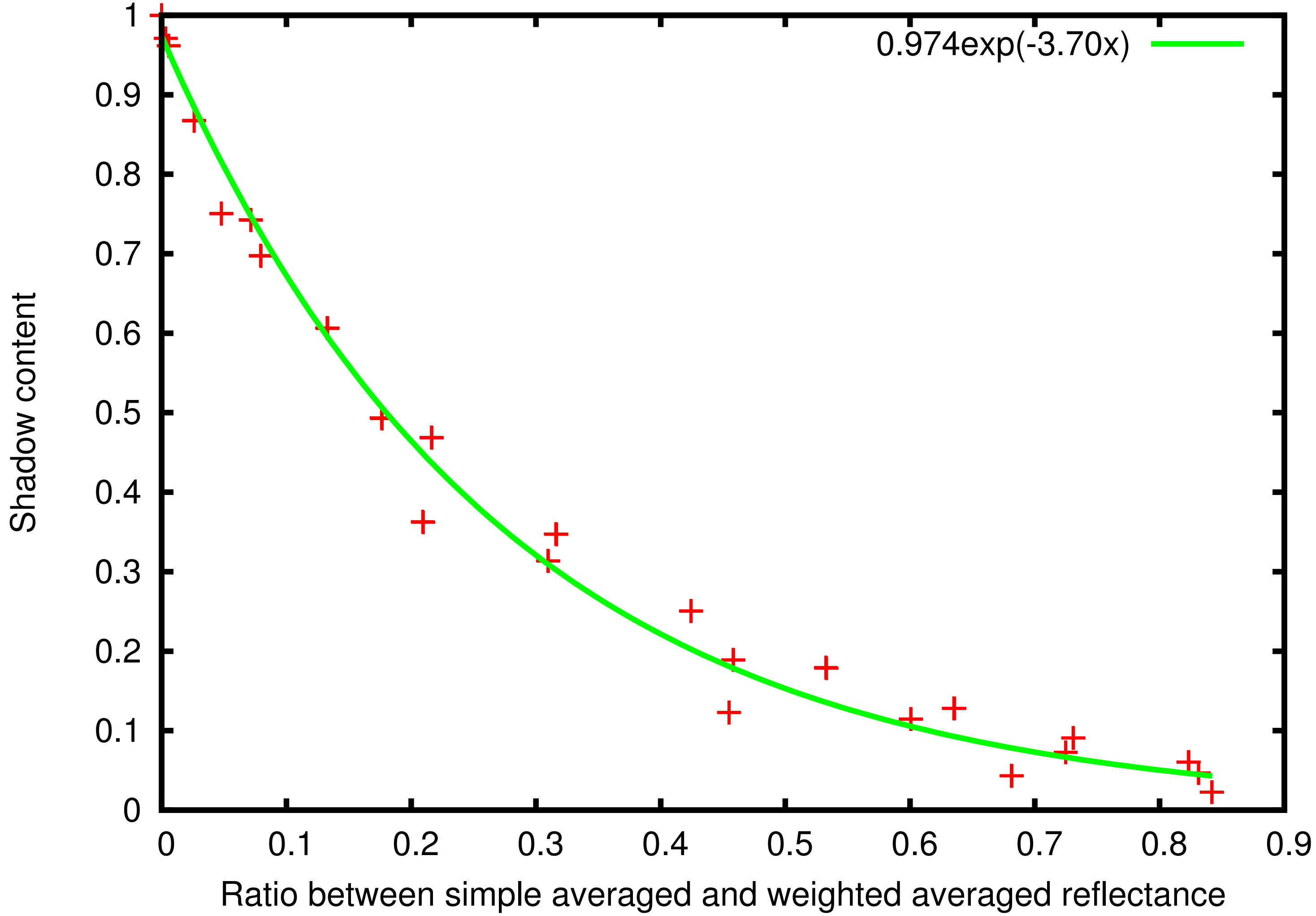
ρ_i	Uniform random number within the range of 0 – 0.1, 0 – 0.3, 0 – 0.5, 0 – 0.7, 0 – 0.9
w_i	Uniform random number within the range of 1.0×10^{-10} – 1.0×10^{-6}
$1 - \cos(\theta'_{si})$	Log–normal distribution with the average of 0.1 – 0.9 and the standard deviation of 0.2, 0.4, 0.6





Definition of SI (*contd.*)

$$SI = a \exp[b \sum w_i \cos(\theta'_{si}) \frac{\rho_i}{\rho}]$$



Definition of SI ($contd.$)

How to define $\sum w_i \cos(\theta'_{si})\frac{\rho_i}{\rho}$

Satellite derived reflectance: $r = \frac{\pi I_s}{F_r \cos(\Theta'_s)+F_d}$,
(Θ'_s: Solar zenith angle or Incident angle from DEM)

$$r = \frac{F_r \sum w_i \cos(\theta'_{si})\frac{\rho_i}{\rho} + F_d}{F_r \cos(\Theta'_s) + F_d}\rho$$

$F_r \gg F_d$ case (SWIR), $F_d \simeq 0$, $r = \frac{\sum w_i \cos(\theta'_{si})\frac{\rho_i}{\rho}}{\cos(\Theta'_s)}\rho$

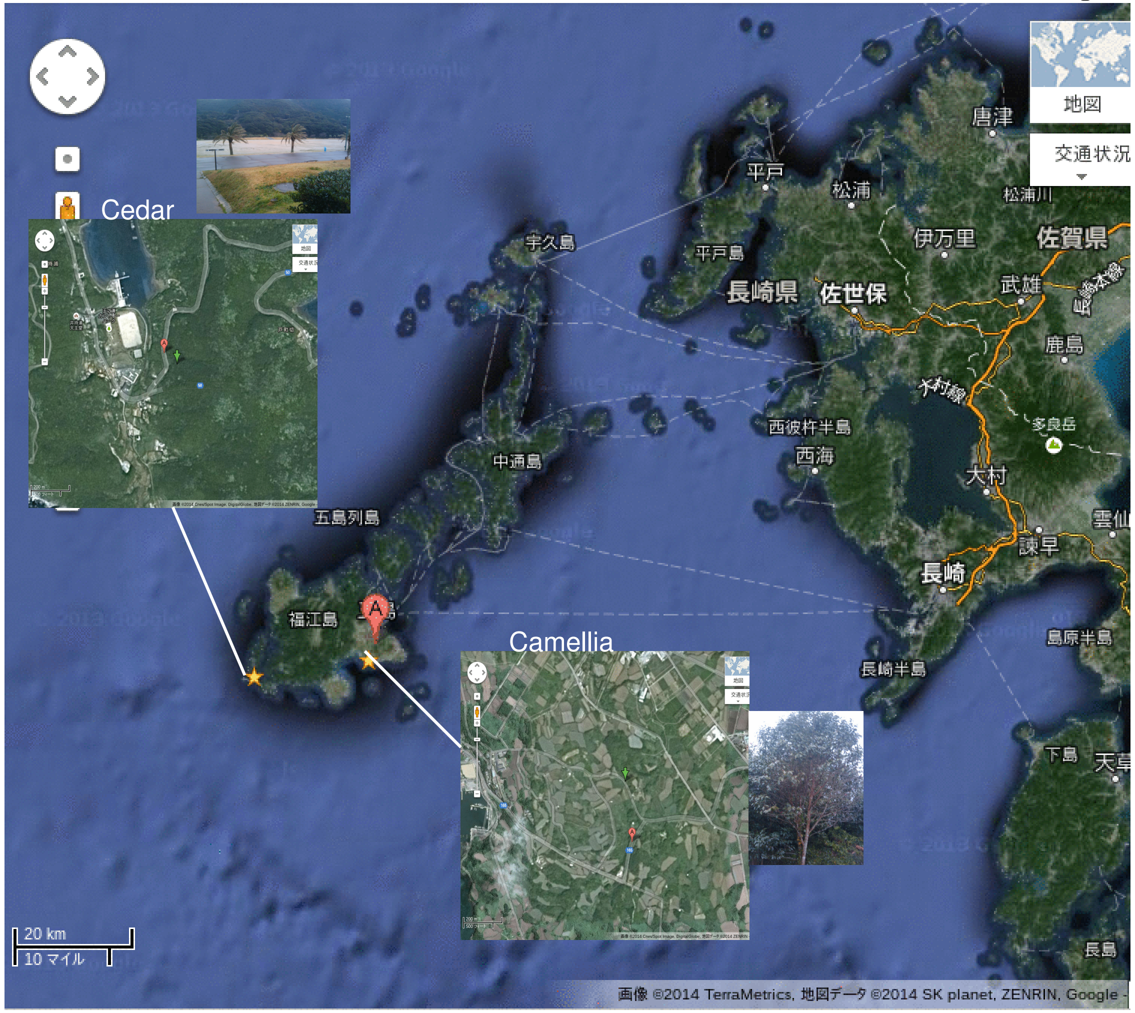
$$\sum w_i \cos(\theta'_{si})\frac{\rho_i}{\rho} = \frac{r}{\rho}\cos(\Theta'_s)$$

$$\Downarrow$$

$$SI = a\exp[b\frac{r}{\rho}\cos(\Theta'_s)],\ \text{(in SWIR)}$$

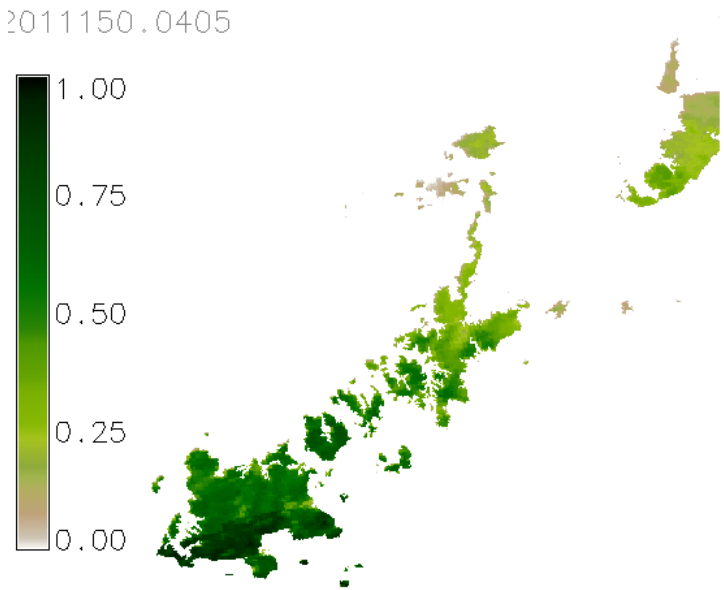
The average reflectance ρ is not undefined.

Example



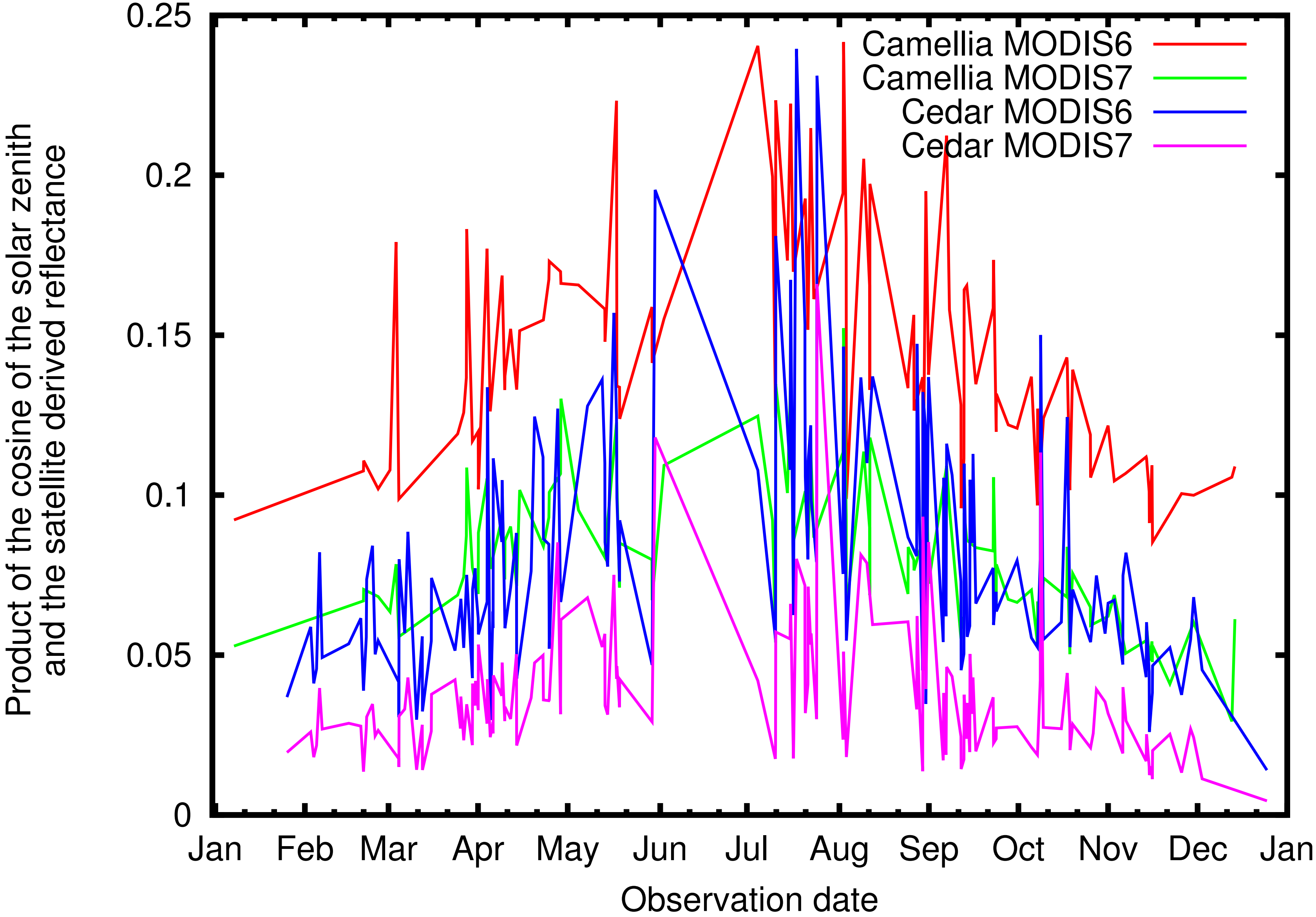
Camellia plantation: 32.648373N, 128.82566E

Cedar forest: 32.617237N, 128.618411E



- TERRA, AUQA/MODIS surface reflectance (2011 Jan. – Dec.)
- Cloud flag

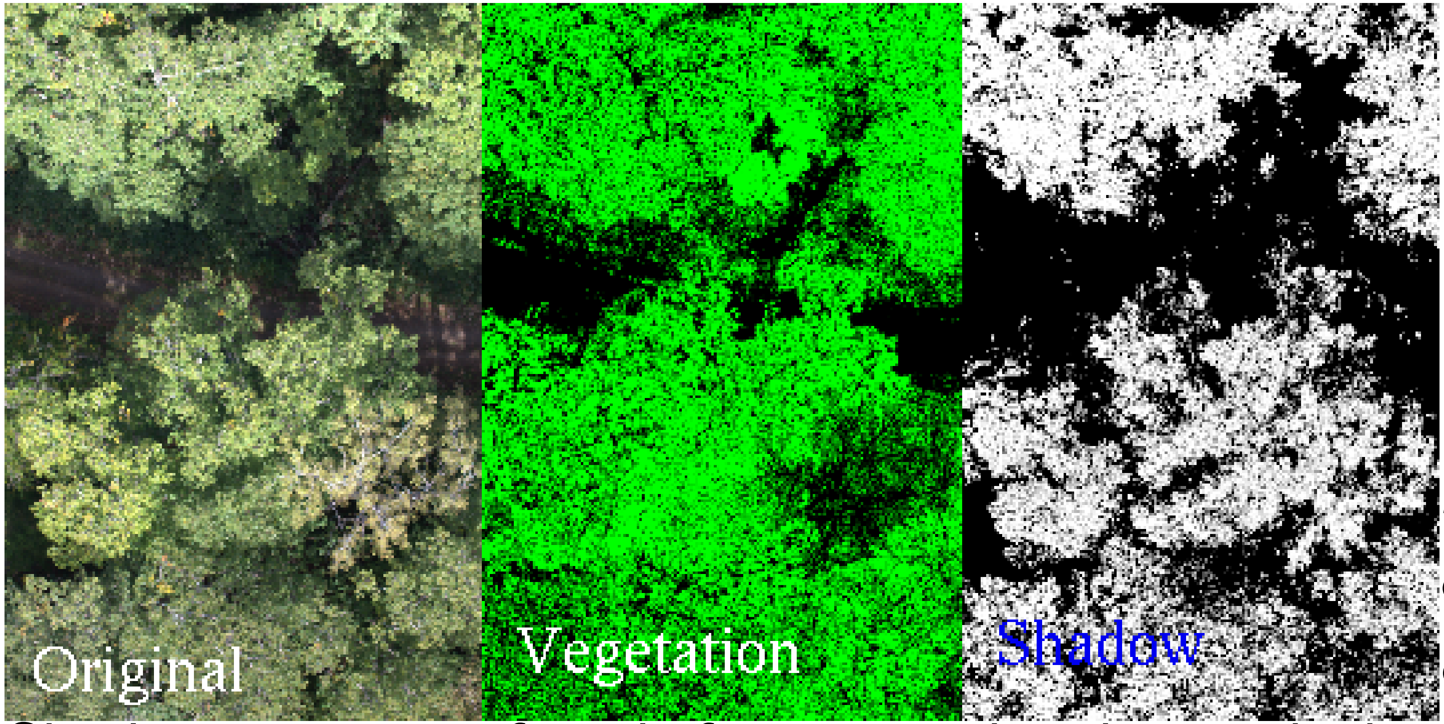
Result

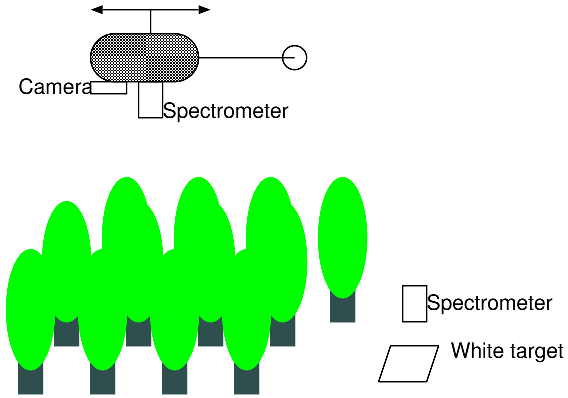


0.25
0.2
0.15
0.1
0.05
0
Product of the cosine of the solar zenith
and the satellite derived reflectance
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Observation date
Camellia MODIS6
Camellia MODIS7
Cedar MODIS6
Cedar MODIS7

Validation scheme

Shadow content estimation from the camera image





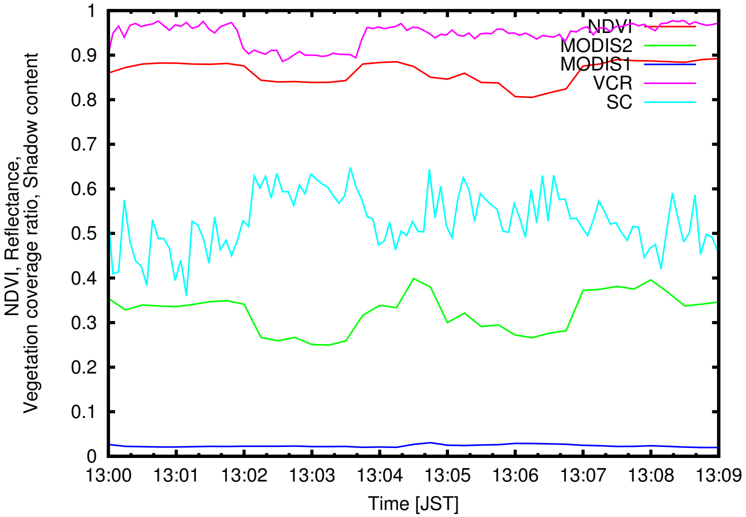
Spectrometer and camera observation with the constant time interval

Shadow content of each frame can be the truth dataset.

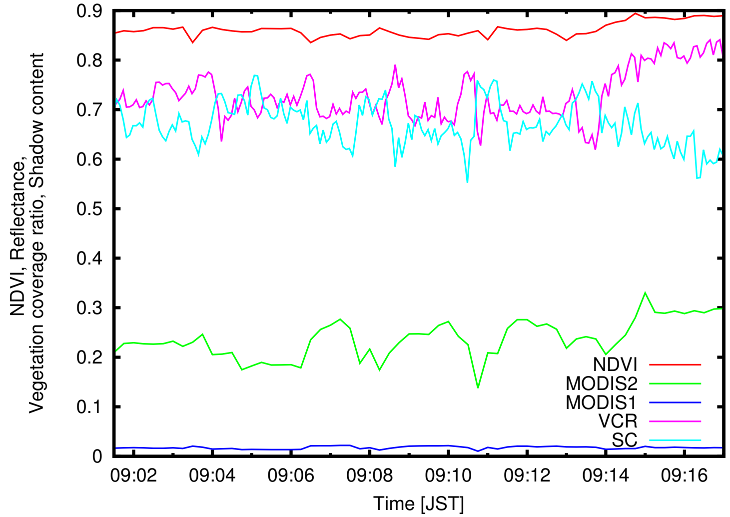
Observation using RC helicopter, 19 - 23 Spt. @Uryu, Hokkaido

- Spectrometer: Eko MS720(VNIR), converted into MODIS chs. 1 and 2 reflectance
- RICOH GR DIGITAL III(19), CANON EOS7D(22, 23)

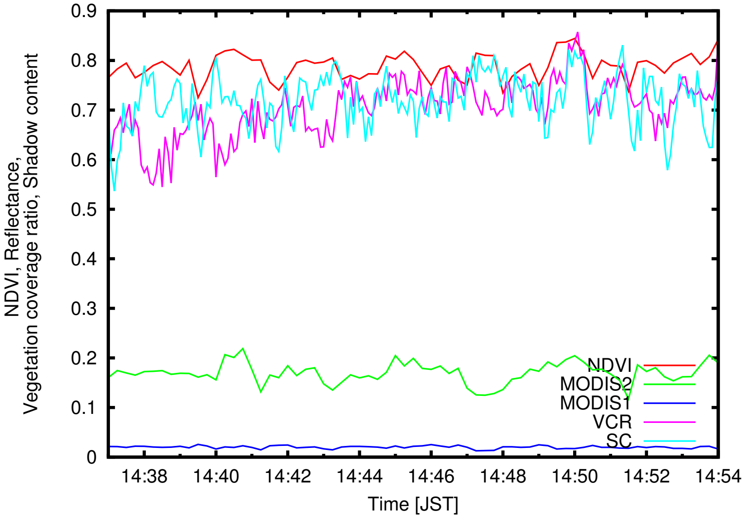
Results



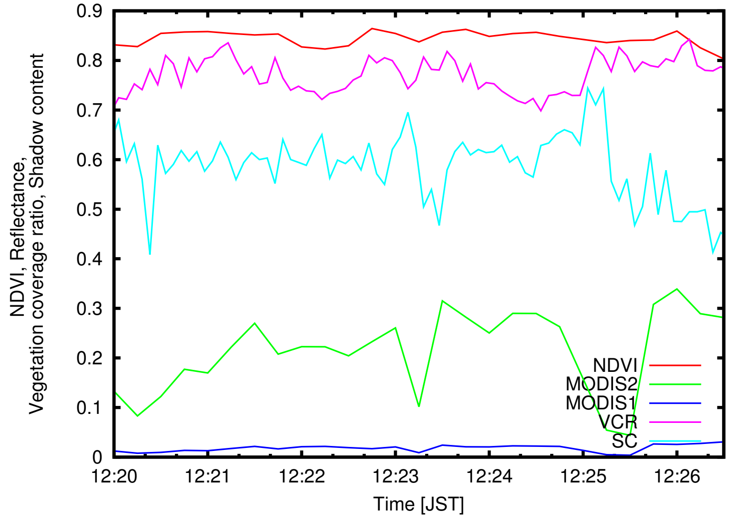
44.3459N, 142.2866E



44.3325N, 142.3038E



44.3985N, 142.2041E



44.3325N, 142.3030E

Conclusions

- From the reflectance scaleup scheme and the numerical simulation, the shadow index is defined as the shadow content within a pixel.
- From the MODIS surface reflectance product, the proposed definition shows the difference between the conifer and the broadleaf.
- The camera based validation scheme is proposed and this shows the validity.
- The definition of the average reflectance is necessay as well as the QA field definition.