Discussion of vicarious calibration of GOSAT/TANSO-CAI UV-band (380nm) and aerosol retrieval in wildfire region in the OCO-2 and GOSAT observation campaign at Railroad Valley in 2016

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A23A-0181

GOSAT/TANSO-CAI

The GOSAT (Greenhouse gases Observing SATellite) is a satellite to monitor the concentration of greenhouse gases, i.e., carbon dioxide (CO2) and methane (CH4), from space.

The satellite has two sensors, TANSO-FTS (Thermal And Near-infrared Sensor for carbon Observation; Fourier Transform Spectrometer) and TANSO-CAI (Cloud and Aerosol Imager).

Table 1. Observation orbit of GOSAT (http://www.gosat.nies.go.jp/index.html)

Orbiter	Sun-Synchronous Sub-Recurrent
Altitude	666 km
Inclination	98.05gedree
Mean local solar time on descending	1300±0:15
Launch date	12:54, January 23, 2009

Table 2. Specifications of GOSAT/CAI (http://www.gosat.nies.go.jp/index.html)

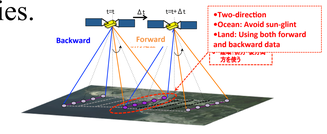
	Band-1	Band-2	Band-3	Band-4
Center wavelength [nm]	380	674	870	1600
Band width [nm]	20	20	20	90
Swath [km]	1000	1000	1000	750
Instant field of view [km]	0.5	0.5	0.5	1.5

TANSO-FTS is the main sensor of GOSAT and observes NIR and TIR spectral to derive CO2 and CH4.

TANSO-CAI is a supplement sensor of TANSO-FTS, dedicated to measure cloud and aerosol properties.

GOSAT-2/CAI-2

Cloud and Aerosol Imager - 2 (TANSO-CAI-2)										
Items	**Specifications**									
Band	1	2	3	4	5	6	7	8	9	10
Center wavelength [nm]	343	443	674	869	1630	380	550	674	869	1630
Band width [nm]	20	20	20	20	90	20	20	20	20	90
Line of sight [deg]	+20					-20				
IFOV [km]	0.5				1	0.5				1
Swath [km]	1000									



- Both forward and backward viewing
  - Avoid sun glint when cloud is detected.
  - Information of aerosol, slightly increase.
- 10 bands and 7 different wavelength.
- NUV data is useful to retrieve an aerosol absorbing

GOSAT - OCO-2 Calobration campaign 2016 in Railroad valley (RRV)

Objective: Measurement of spectral surface reflectance for GOSAT/ CAI and GOSAT-2/CAI-2 calibration at around near UV (NUV) region.

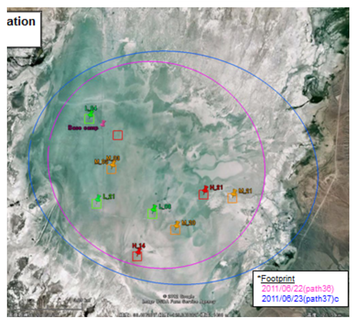
Place and location: Railroad Valley field - Nevada, USA
Base-camp: 38.49703 N; 115.69013 W,
Height : about 1435m,

Period: June 27 – July 3, 2016

Instruments:

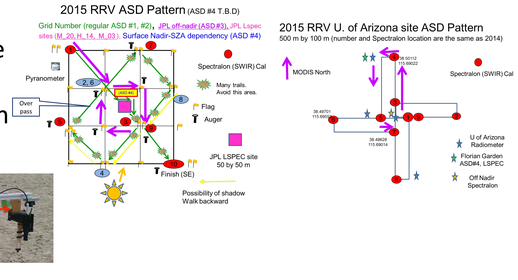
- Visible and UV spectrometer（USB4000-UV-VIS）
- Spectralon
- 74-uv collimating lens (200-2000nm) (φ=5mm, f=10mm)

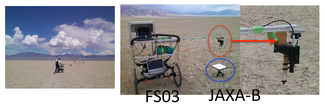
Method : Measure the spectral surface reflectance at two places (500m square areas) in RRV between 30 minutes before and after passing through GOSAT.



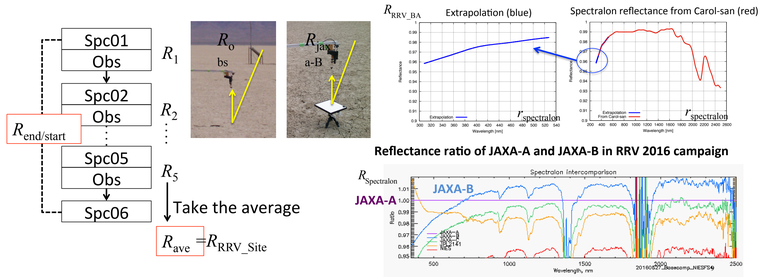
UV surface reflectance

Method :
Walk with UV4000in the calibration area, 500m square area, as shown in right figures.





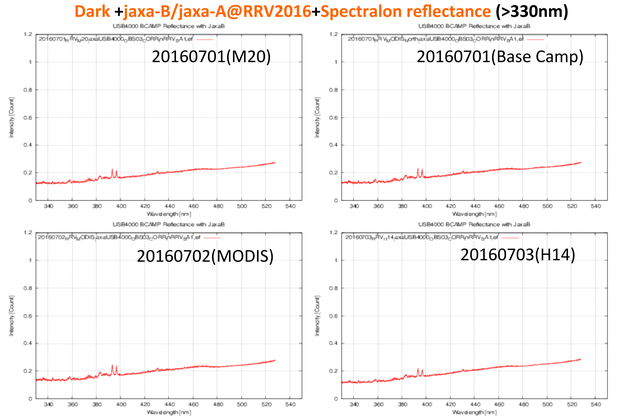
Calculate surface reflectance:



$$R_{\mathrm{RRV\_Site}} = \frac{(DN_{\mathrm{RRV\_Site}} - dark)}{[(DN_{\mathrm{RRV\_JAXA\text{-}B}} - dark) / R_{\mathrm{RRV\_BA}} / R_{\mathrm{Spectralon}}]}$$

$R_{\mathrm{RRV\_Site}}$	: Surface albedo
$DN_{\mathrm{RRV\_Site}}$	: Intensity over RRV surface [count]
$DN_{\mathrm{RRV\_JAXA\text{-}B}}$	: Intensity of Spectralon JAXA-B [count]
$R_{\mathrm{RRV\_BA}}$	: Reflectance ratio of JAXA-A and JAXA-B in RRV 2016 campaign
$R_{\mathrm{Spectralon}}$	: Spectralon reflectance data
dark	: Dark data by HgAr light source spectral
RRV_Site	: Site name in RRV: M20; H14; MODIS; BaceCamp(=MODIS North)

Dark +jaxa-B/jaxa-A@RRV2016+Spectralon reflectance (>330nm)

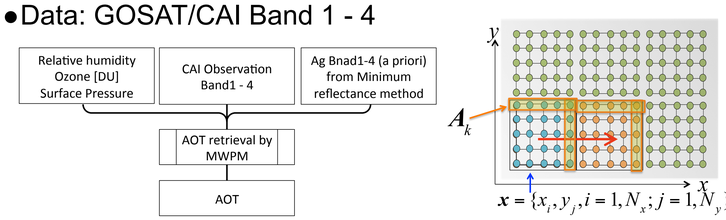


Summary (Problem & future work) :

- The reflectance of Spectralon in the ultraviolet region is greatly different for each Spectralon.
- BRDF effect & degradation at NUV
- How to calibrate 340 nm measurement

Aerosol retrieval

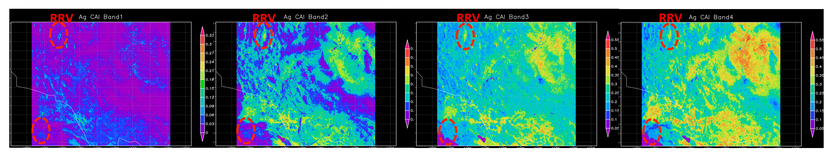
- Derive surface reflectance by Minimum reflectance method From one month data (before and after 15 days)
- MWP method = Multi-wavelength and -pixel method (Hashimoto, PhD, 2014)
- Data: GOSAT/CAI Band 1 - 4



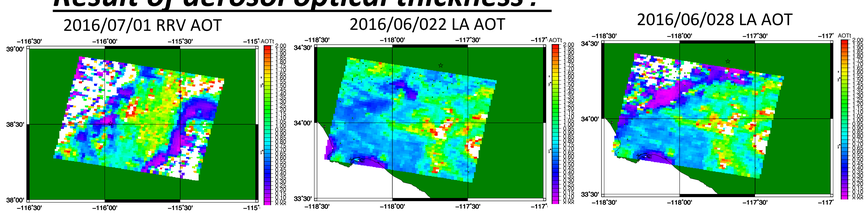
$$\phi = \left(\boldsymbol{R} - \boldsymbol{f}(\boldsymbol{u})\right)^{\mathrm{T}} \mathbf{S}_e^{-1} \left(\boldsymbol{R} - \boldsymbol{f}(\boldsymbol{u})\right) + \left(\boldsymbol{u} - \boldsymbol{u}_a\right)^{\mathrm{T}} \mathbf{S}_a^{-1} \left(\boldsymbol{u} - \boldsymbol{u}_a\right) + \sum_k \gamma (\boldsymbol{A}_k + \mathbf{D}_k \boldsymbol{u})^{\mathrm{T}} (\boldsymbol{A}_k + \mathbf{D}_k \boldsymbol{u})$$

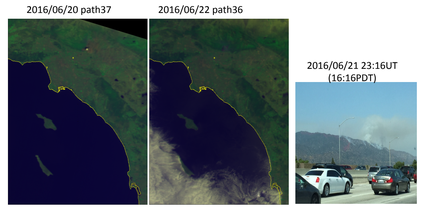
τ_{fine}	: Aerosol optical thickness (AOT) of fine mode at wavelength 500nm
τ_{coarse}	: AOT of coarse mode
A_g	: Ground surface albedo
λ	: Wavelength
$\mathbf{S_e}$	: Covariance matrix of measurement error
$\mathbf{S_a}$	: Covariance matrix of a priori u_a
$\boldsymbol{A}_k$	: matrix of boundary condition at *k*th (x, y) region
$\mathbf{D_k}$	: secondary differential operator at *k*th (x, y)
γ_k	: Smoothing factor at *k*th (x, y)

Result of surface albedo :



Result of aerosol optical thickness :





Summary :

- The RRV surface albedo@380nm is underestimate? High @674, 870, and 1600nm. => AOT accuracy is Low?
- AOT in LA is high on June 22&28, 2016 (0.4~0.6) due to wild fire?