Data Processing (1)
データ処理手法(1)

Short Wavelength Infrared Bands of the TANSO-FTS
短波長赤外バンド

Tatsuya Yokota 横田 達也

NIES GOSAT Project Leader
Center for Global Environmental Research (CGER)
National Institute for Environmental Studies (NIES), Japan

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  - Solar Fraunhofer lines --- Robert Kurucz's new data
    太陽フラウンホファー線情報: Kurucz博士の新データ
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- Data filtering データの事前フィルタリング
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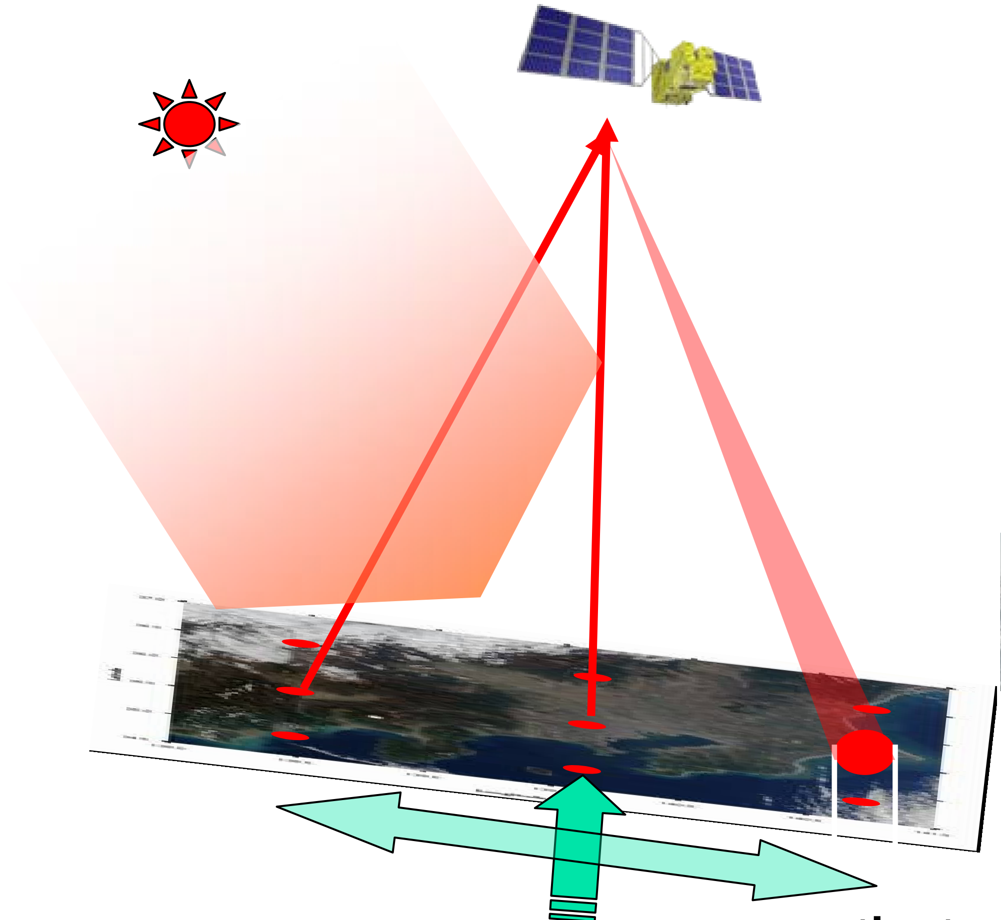
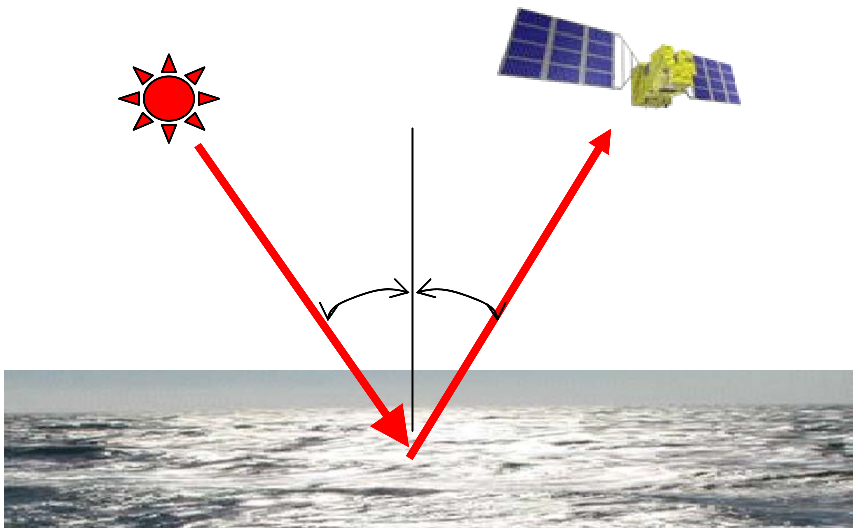
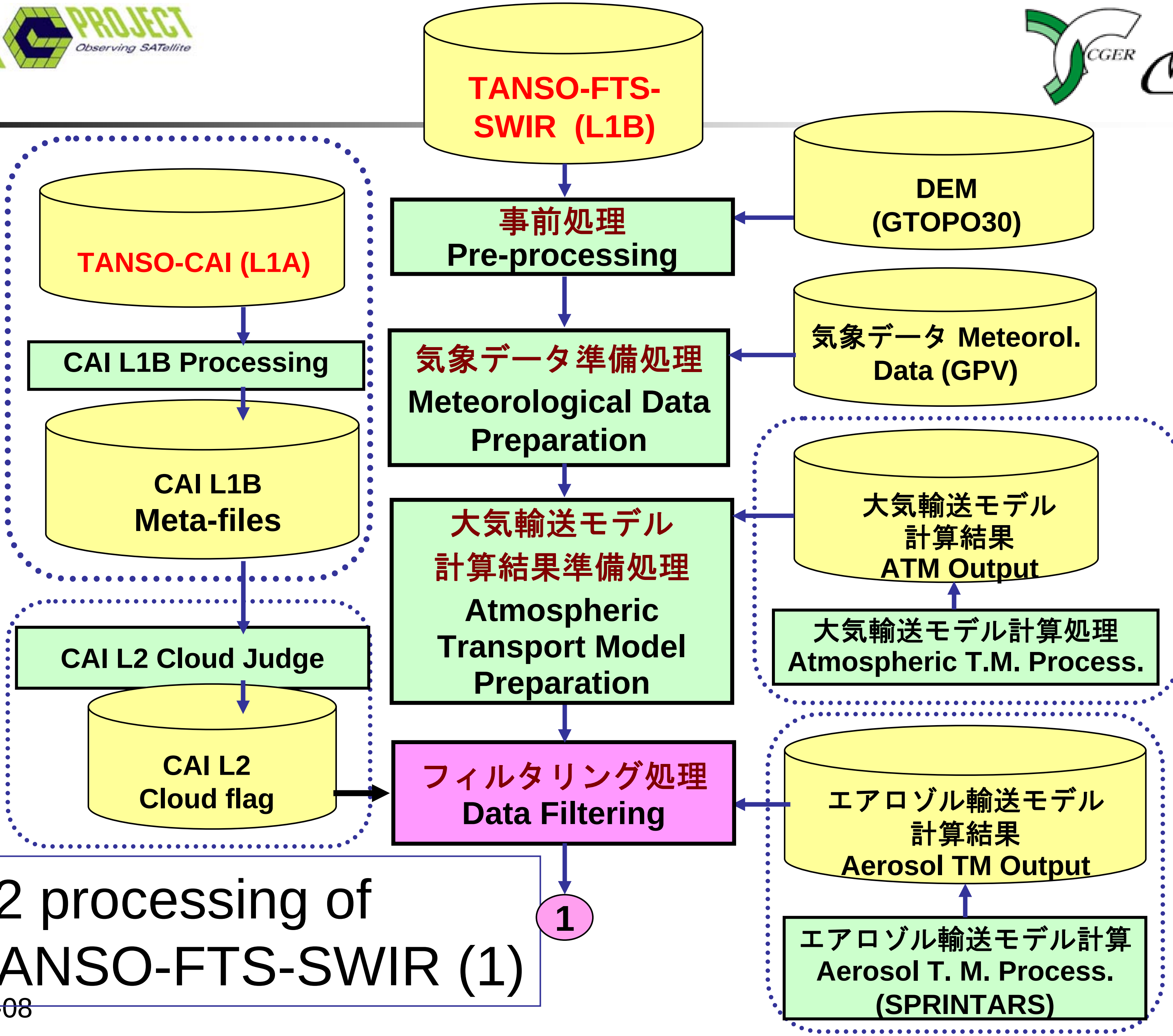
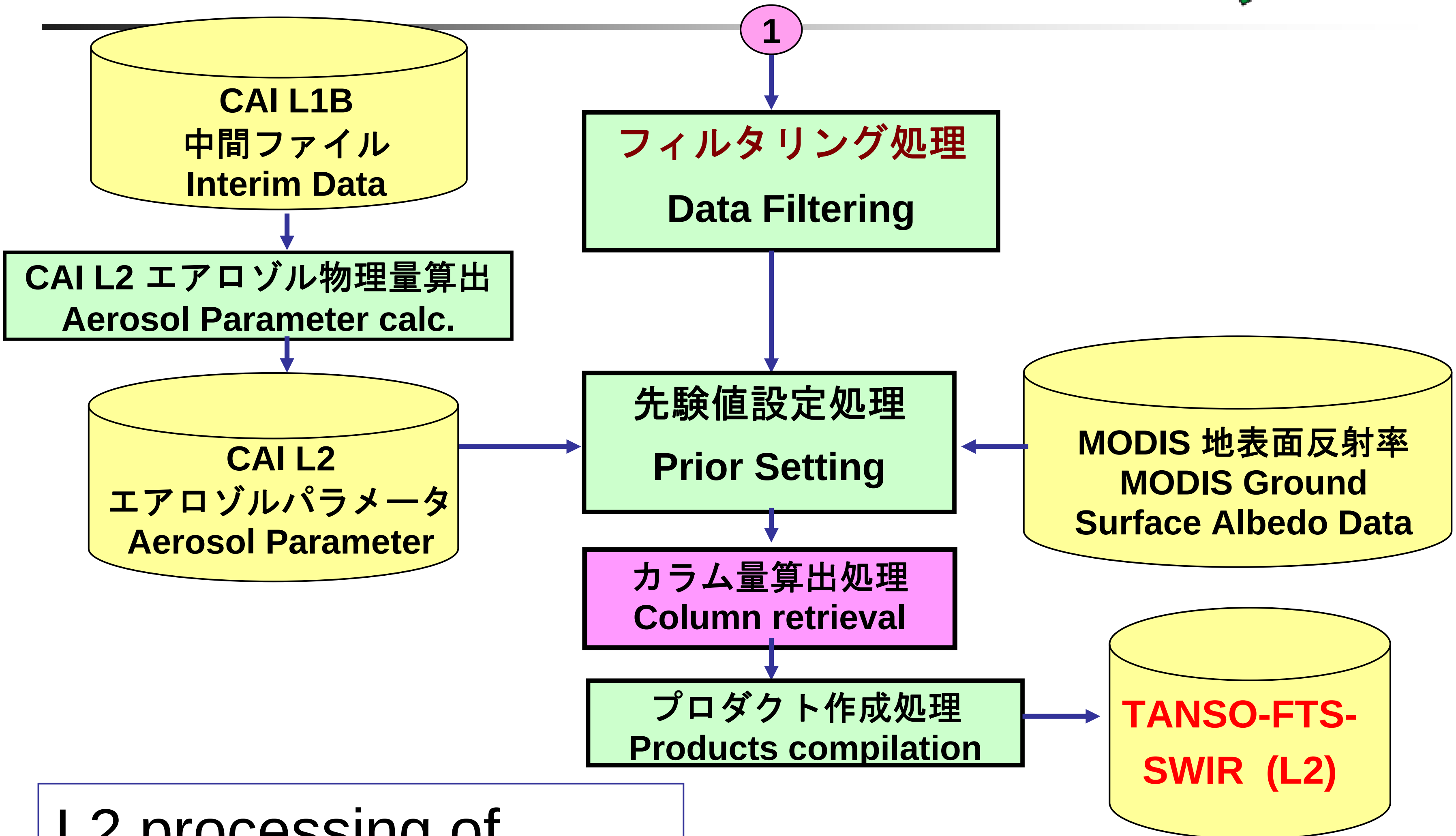
Observational Mode (TANSO-FTS)





L2 processing of TANSO-FTS-SWIR (1)

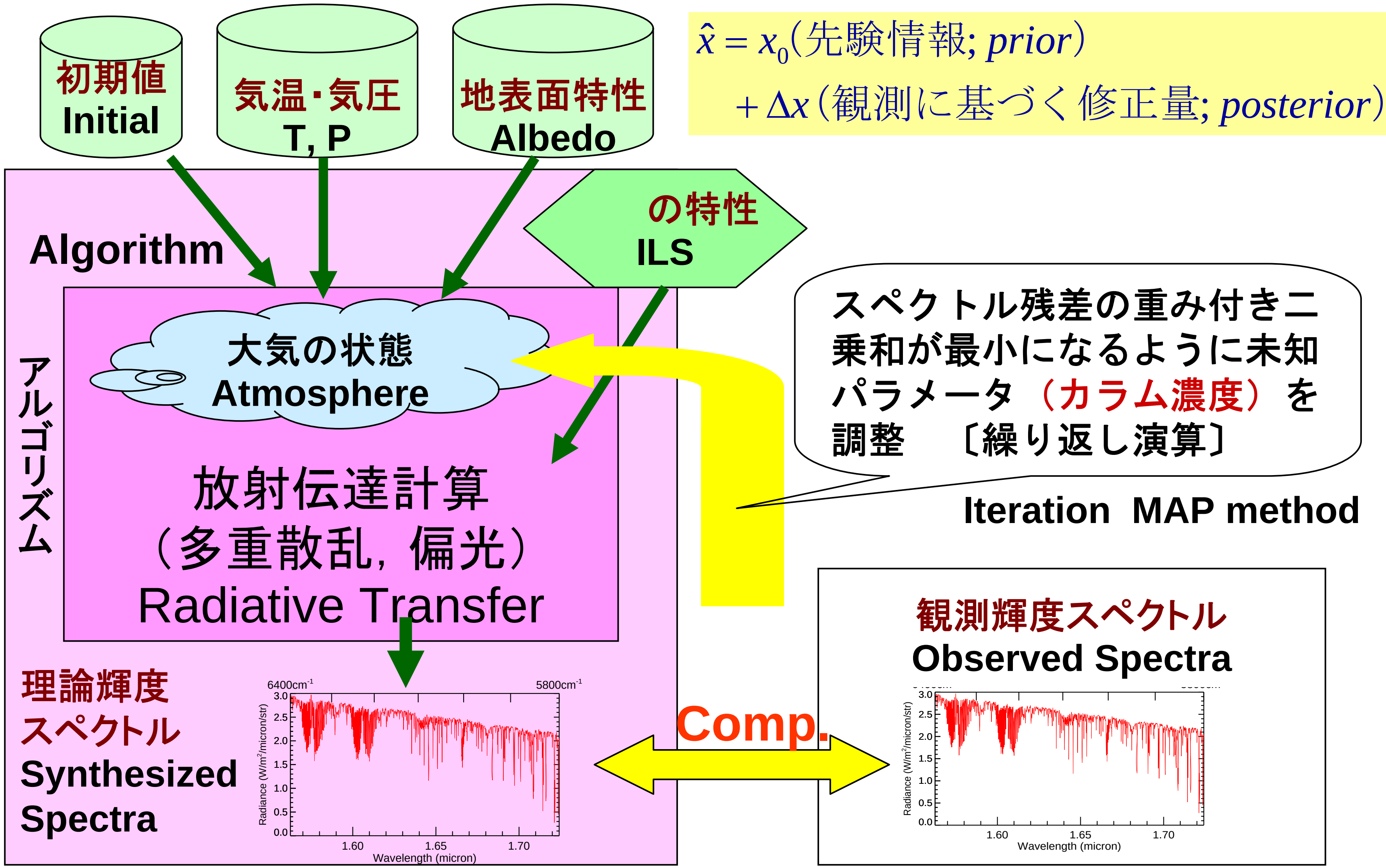




L2 processing of TANSO-FTS-SWIR (2)

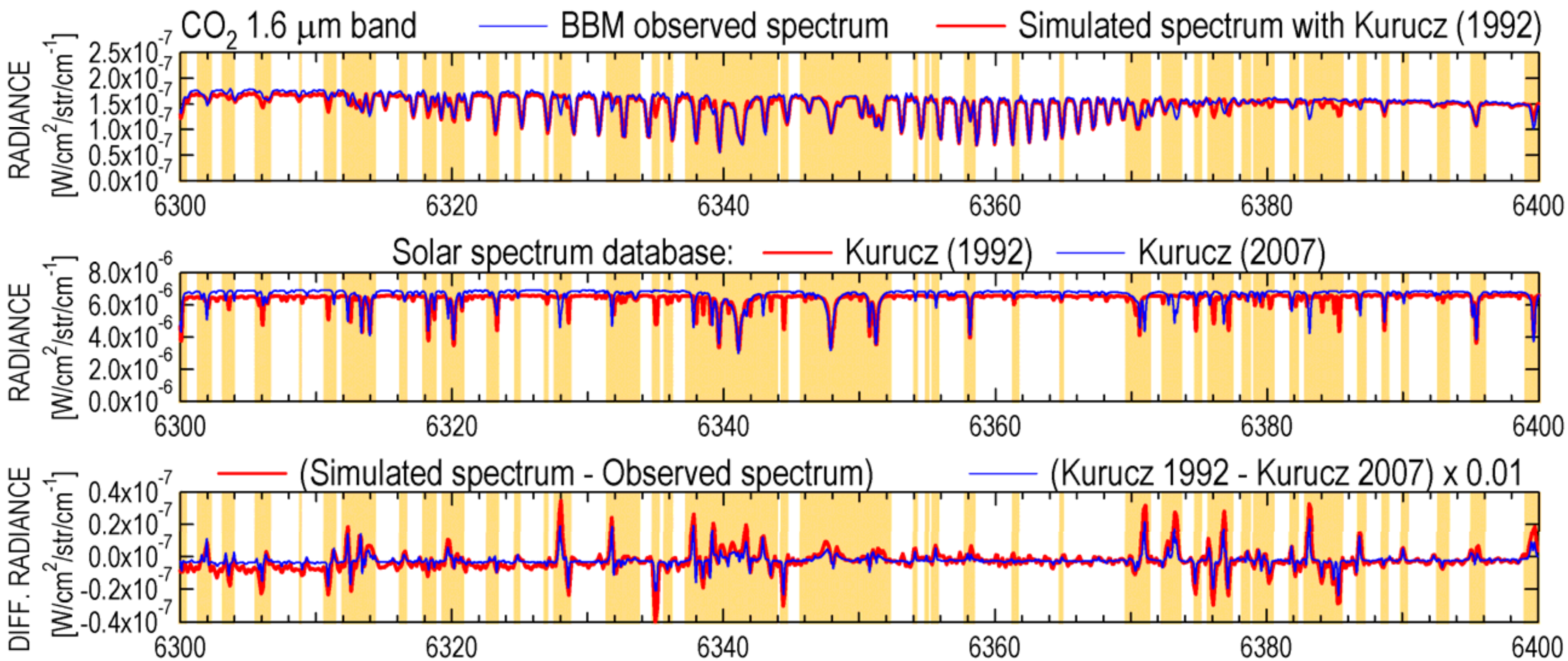
TANSO-FTS SWIR L2 Data Processing

$$\hat{x} = x_0(\text{先験情報; }prior) + \Delta x(\text{観測に基づく修正量; }posterior)$$



Channel selection and Solar Fraunhofer lines

During the analyses of the field campaign, we found the disagreement between the Fraunhofer lines of the solar spectrum database and those of observed spectrum. The solar spectrum database are updated, but channels overlapped with the Fraunhofer lines are excluded in the retrieval analysis for safety.

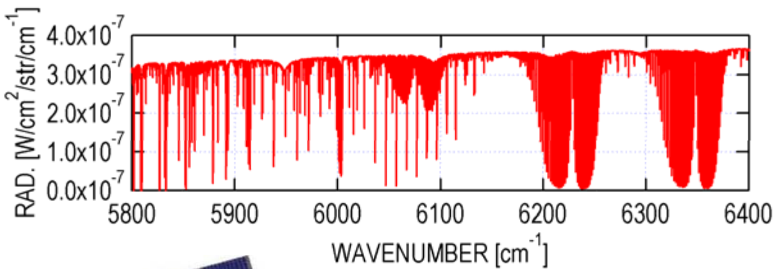


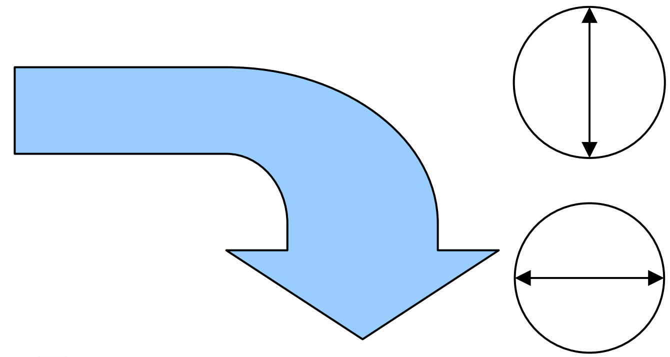
(Analyzed by Y. Yoshida (NIES))

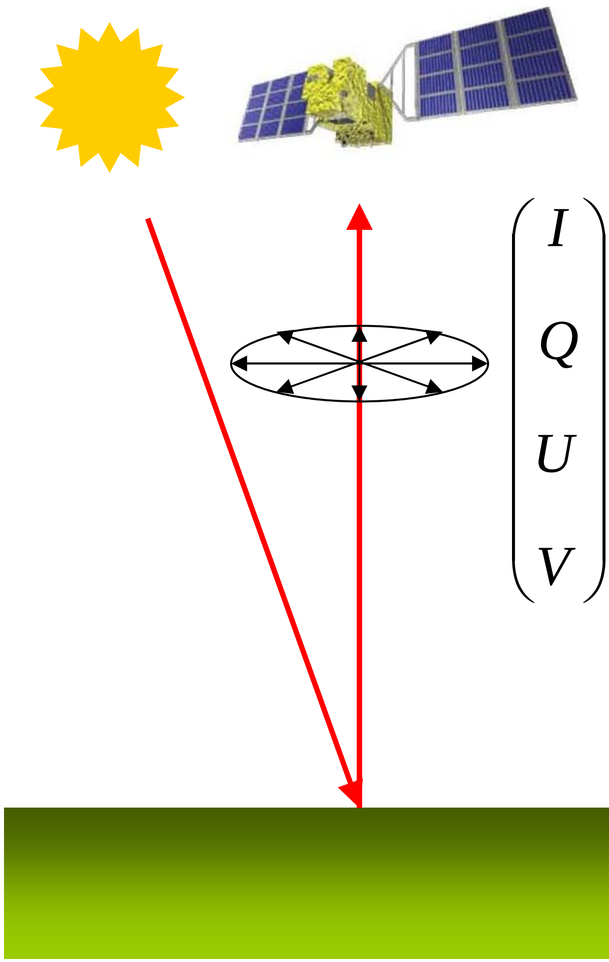
TANSO-FTS Configuration

Ground Pointing Mechanism and Fore optics	Configuration	2-axes scanner (fully redundant) for pointing			
	Scanning	Cross Track (+/- 35 deg) Along Track (+/- 20 deg)			
	Field of view	IFOV <10.5 km 790 km (scan width) (latitude of 30 deg)			
Fourier Transform Spectro-meter	Speed	0.25, 0.5, 1 (Interferogram)/sec			
	Spectral band	1P, 1S	2P, 2S	3P, 3S	4
	Coverage	0.75 μm - 0.78 μm	1.56 μm - 1.72 μm	1.92 μm - 2.08 μm	5.5 μm - 14.3 μm
	resolution (cm^{-1})	0.5	0.2	0.2	0.2
	Detector	Si	InGaAs	InGaAs	PC-MCT
	Calibration	Solar Irradiance, Deep Space, Moon, Diode Laser			Blackbody, Deep space

Incident light is devided by two polarized component by PBS.

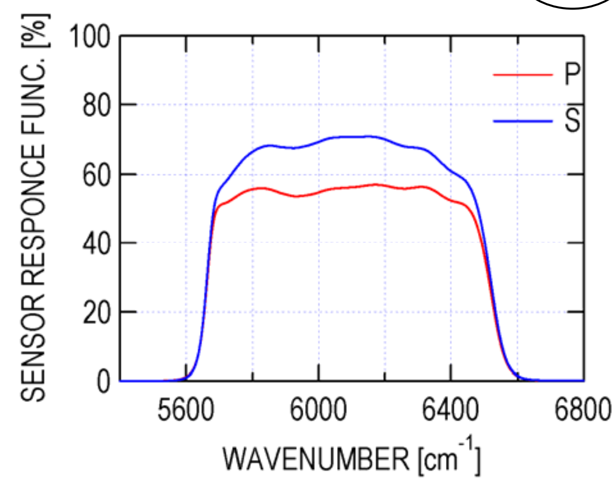


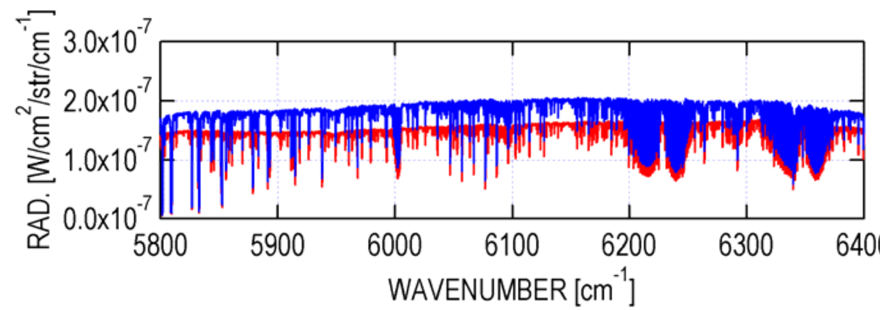




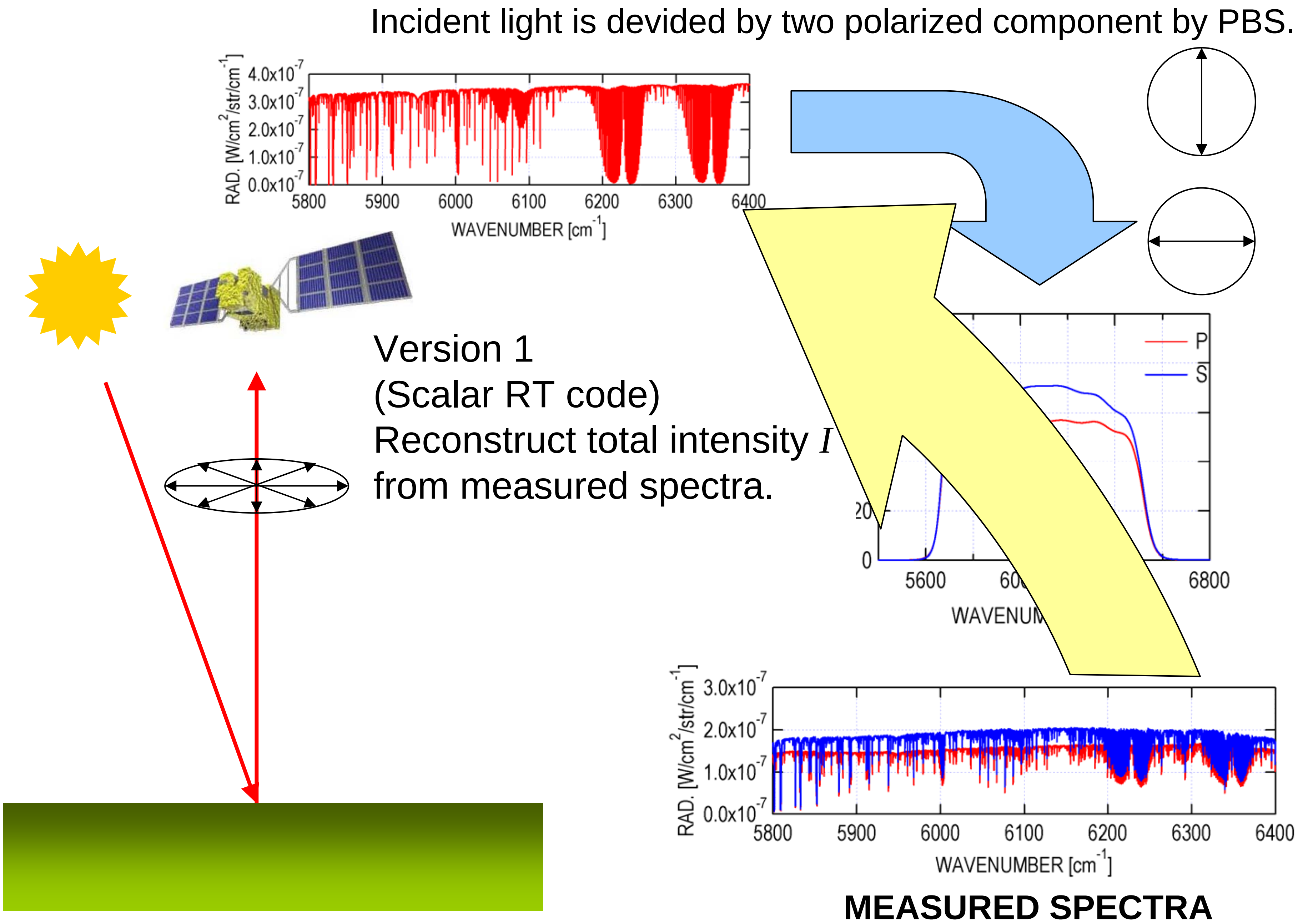
$$\begin{pmatrix} I \\ Q \\ U \\ V \end{pmatrix}$$

To simulate the observed spectra, we have to know I, Q, and U of the incident light.

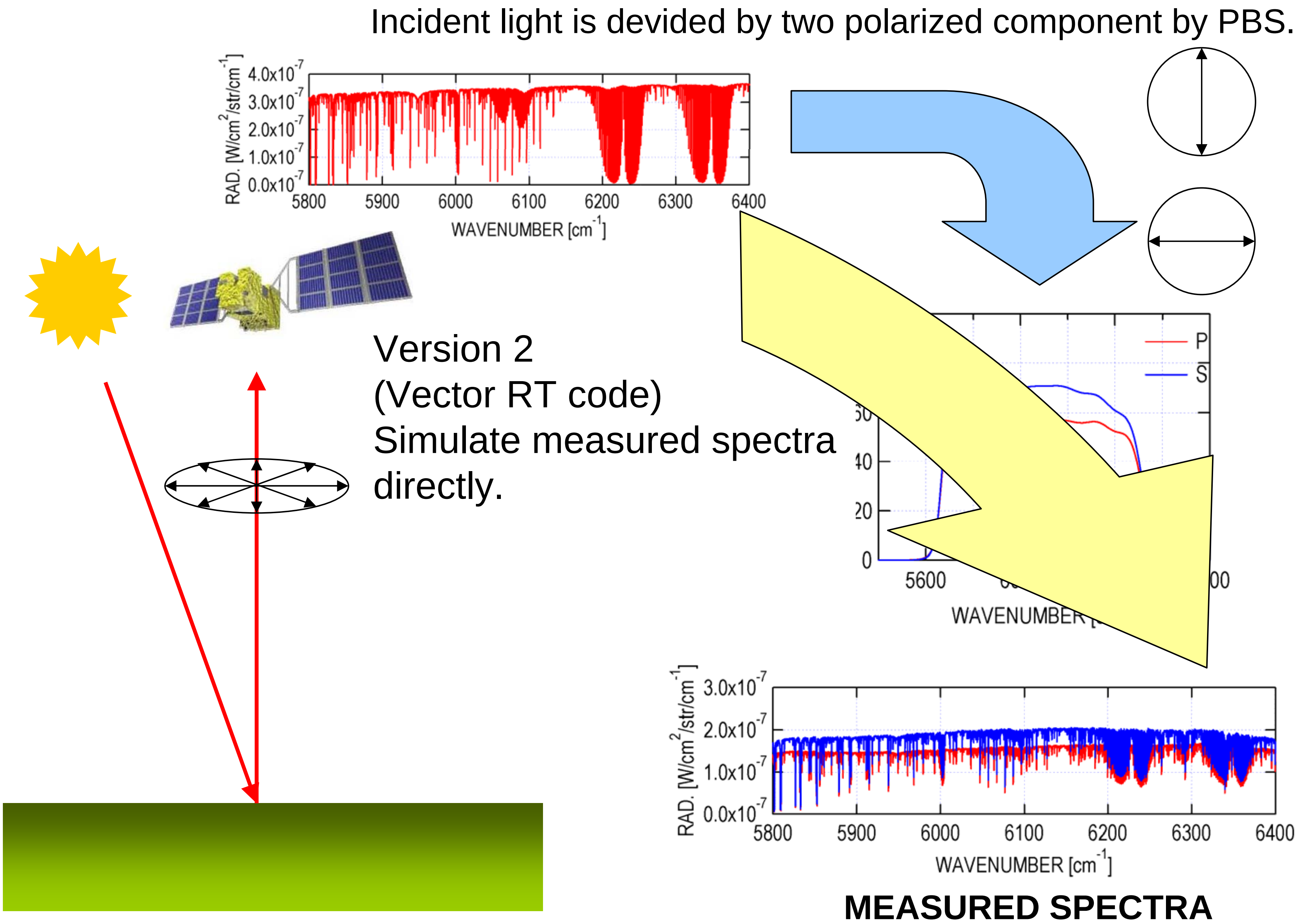




MEASURED SPECTRA



Incident light is devided by two polarized component by PBS.
RAD. [W/cm2/str/cm-1]
4.0x10-7
3.0x10-7
2.0x10-7
1.0x10-7
0.0x10-7
5800
5900
6000
6100
6200
6300
6400
WAVENUMBER [cm-1]
Version 1
(Scalar RT code)
Reconstruct total intensity I
from measured spectra.
P
S
0
5600
6800
RAD. [W/cm2/str/cm-1]
3.0x10-7
2.0x10-7
1.0x10-7
0.0x10-7
5800
5900
6000
6100
6200
6300
6400
WAVENUMBER [cm-1]
MEASURED SPECTRA



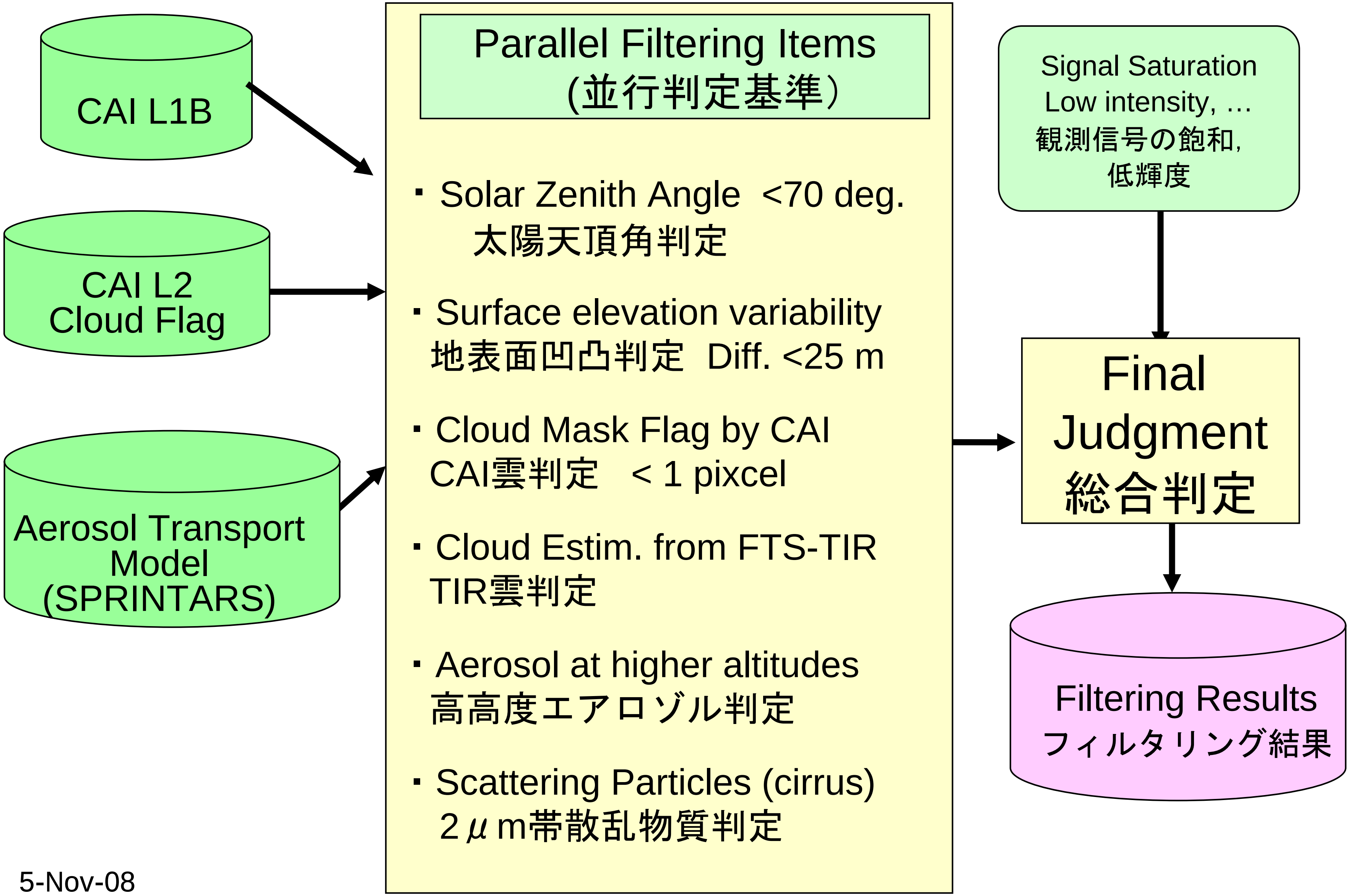
Incident light is devided by two polarized component by PBS.
RAD. [W/cm^2/str/cm^-1]
4.0x10^-7
3.0x10^-7
2.0x10^-7
1.0x10^-7
0.0x10^-7
5800
5900
6000
6100
6200
6300
6400
WAVENUMBER [cm^-1]
Version 2
(Vector RT code)
Simulate measured spectra
directly.
P
S
5600
WAVENUMBER
RAD. [W/cm^2/str/cm^-1]
3.0x10^-7
2.0x10^-7
1.0x10^-7
0.0x10^-7
5800
5900
6000
6100
6200
6300
6400
WAVENUMBER [cm^-1]
MEASURED SPECTRA

Radiative transfer model: Hstar and Pstar2.

- **High spectral resolution version of the System for Transfer of Atmospheric Radiation (Hstar);** [Nakajima et al.]
  - Scalar radiative transfer (radiance calculation only).
  - **Hybrid model: Discrete-ordinate / matrix-operator (adding) method** (Nakajima and Tanaka, 1986).
  - Multilayer multiple scattering media.
  - The delta-M truncation method.
  - Exact single scattering correction; TMS- and IMS-method (Nakajima and Tanaka, 1988).
  - Rough ocean surface model (Nakajima and Tanaka, 1983) / Lambert surface.
  - Direct multi-solar beam (for LUT calculation).
  - Arbitrary viewing geometry (Source function integration).

- **Vector radiative transfer model (Pstar2).**
  - Same as the above radiative transfer scheme.
  - Coupled atmosphere-ocean system including polarization effect.

Measurement Data Filtering



Operational Data Retrieval Method

- Non-linear Least square fit of the spectra for both SWIR and TIR data
  - Constrained Gauss-Newton Method (Maximum A Posteriori method; MAP)

$$x_{i+1} = x_i + \left(K_i^T S_\varepsilon^{-1} K_i + S_a^{-1}\right)^{-1} \left[K_i^T S_\varepsilon^{-1} \left(y - F(x_i)\right) - S_a^{-1} (x_i - x_a)\right]$$

F(*x*): Radiance Spectrum
K = ∂ *F*(*x*)/ ∂ *x*: Jacobian matrix

$$J(x) = [y - F(x)]^T S_\varepsilon^{-1} [y - F(x)] + (x - x_a)^T S_a^{-1} (x - x_a) \rightarrow \min.$$

- SWIR bands ➔ Column abundances of CO_2 & CH_4
- TIR band ➔ Volume mixing ratio profiles of CO_2

Operational Data Retrieval Method

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$F(x)$: Radiance Spectrum
$K = \partial F(x)/\partial x$: Jacobian matrix

$$J(x) = \left[y - F(x)\right]^T S_\varepsilon^{-1}\left[y - F(x)\right] + \left(x - x_a\right)^T S_a^{-1}\left(x - x_a\right) \rightarrow \min.$$

measurement **a priori**

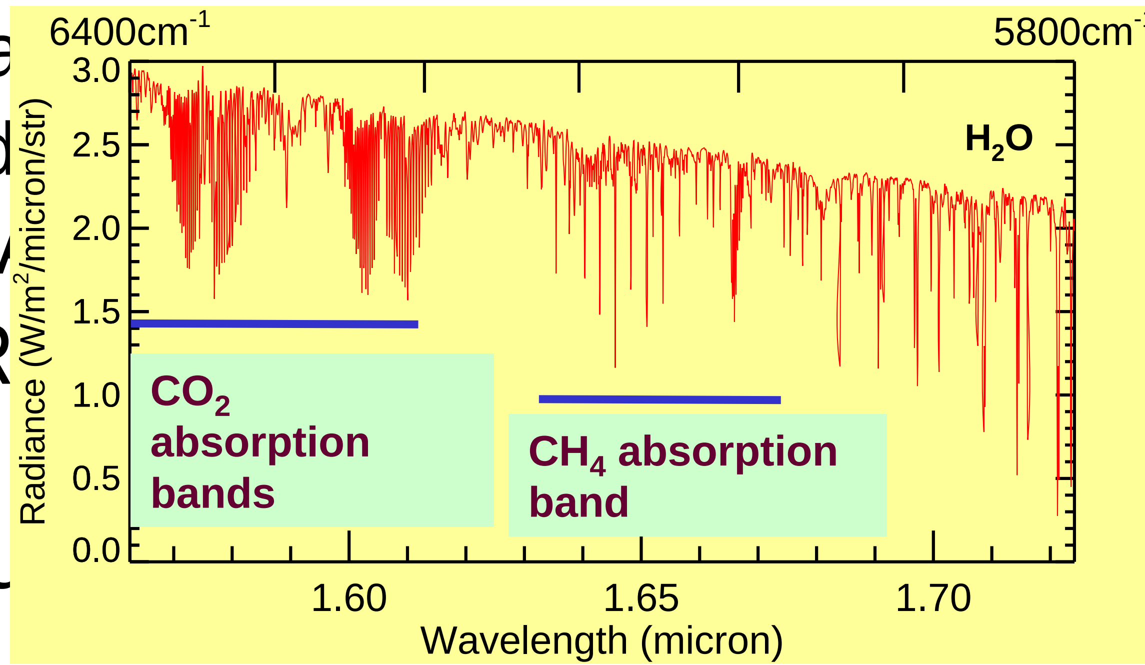
- SWIR bands ➔ Column abundances of CO_2 & CH_4
- TIR band ➔ Volume mixing ratio profiles of CO_2

SWIR Data Retrieval Method

- Simultaneous retrieval of column-GHGs, surface albedo spectra (@Band 2), cirrus parameters (height, optical thickness), and other linear factor possibly caused by instrument calibration error
- CO_2 and CH_4 are retrieved separately
- Non-linear Least square fit of the spectra
  - Constrained Gauss-Newton Method
  - (Maximum A Posteriori method; MAP)
- Interim VMR profile retrieval ➔ Column abundances ➔ X_{CO2}, X_{CH4}
- (Always assuming cirrus-existing condition)

SWIR Data Retrieval Method

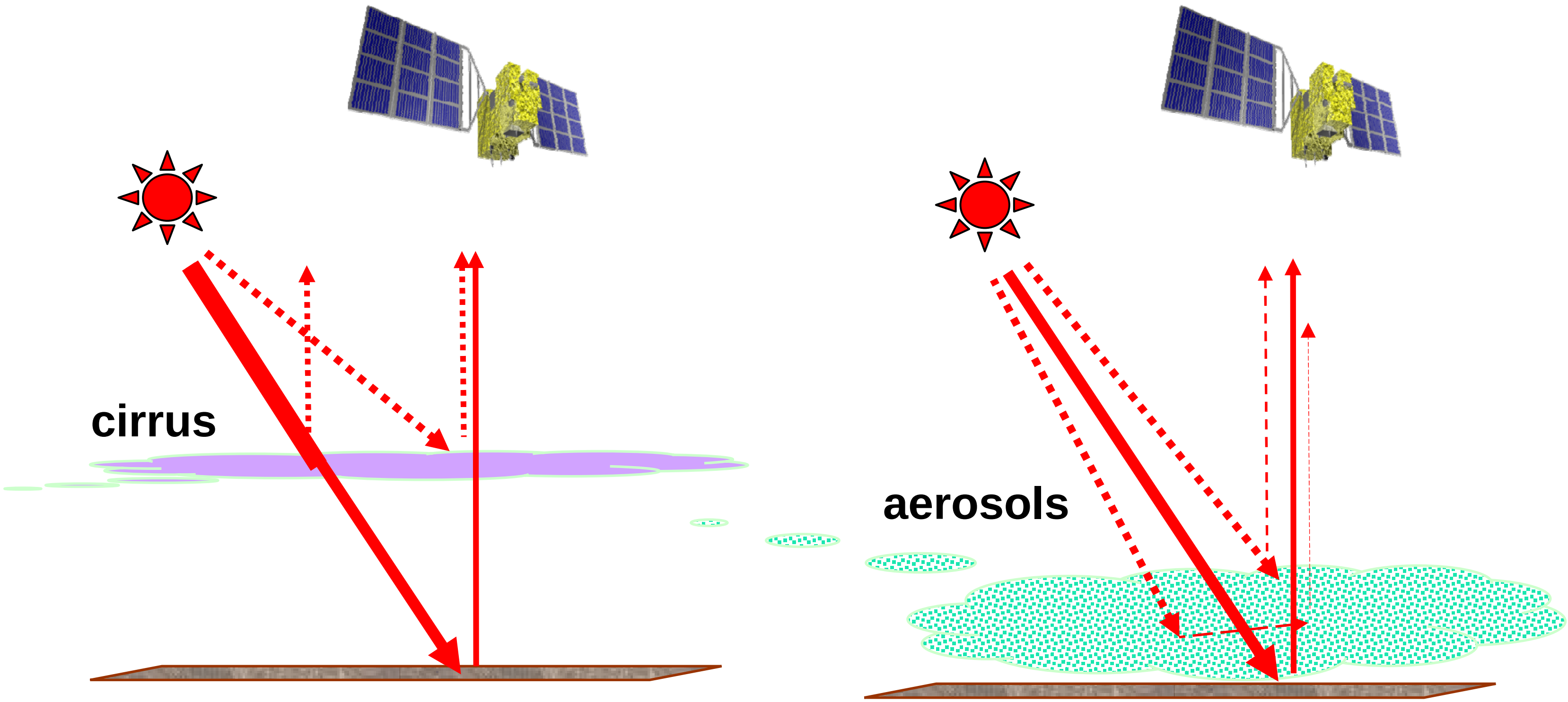
- Simultaneous retrieval of column-GHGs, surface albedo spectra (@Band 2), cirrus parameters (height, optical thickness), and other linear factor possibly caused by instrument calibration error
- CO_2 and CH_4 are retrieved separately
- Non-linear Lea
  - Constrained
  - (Maximum
- Interim VMR abundances
- (Always assu)



Data retrieval simulation under cirrus-existing condition
（巻雲への対処手法）

Retrieval of column-CO_2, ground surface albedo, cirrus height, cirrus optical thickness, …

Reflection from cirrus / aerosol

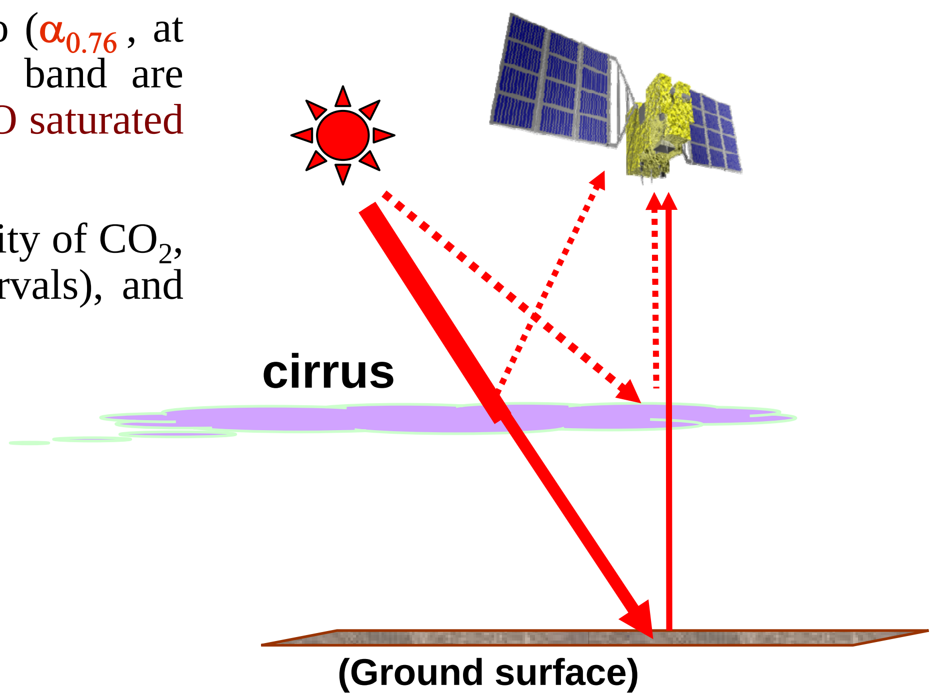


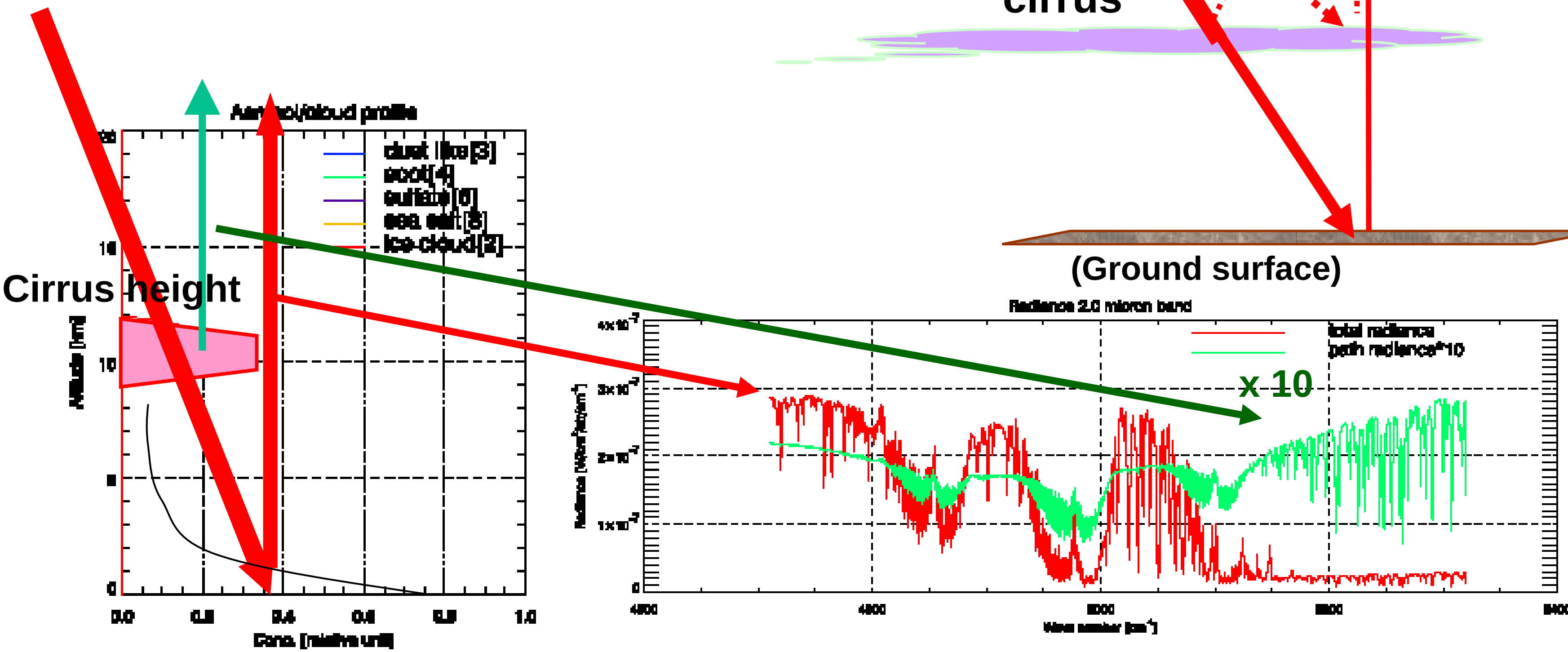
Cirrus effects will be cancelled with a two-step estimation method by using the H_2O saturated spectral region of the 2.0 μm band

Some types of the aerosols (e.g. including large particles) will affect serious error on the retrieval. We are now investigating a way to overcome the aerosol effects.

Info. about cirrus height and OPD

- Step #1: The cirrus optical depth (τ), the cirrus cloud center height (**h**), and ground surface albedo ($\alpha_{0.76}$, at 50 cm^{-1} intervals) at the 0.76 μm (O_2-*A*) band are estimated from the 0.76 μm band and the H_2O saturated spectral region of the 2.0 μm band
- Step #2: Simultaneous retrieval of column density of CO_2, ground surface albedo ($\alpha_{1.6}$ at 50 cm^{-1} intervals), and re-estimation of τ from the 1.6 μm band





Concluding Remarks

ま　と　め

- Key issues of the TANSO-FTS-SWIR processing:
  - Data Filtering & Retrieval
  - 「フィルタリング」と「導出処理」が要点
- GOSAT radiative transfer (DISORT and HSTAR base) codes and data retrieval algorithms (MAP method) will be improved year by year.
  - Polarized data utilization
- 「MAP法」（非線形最小二乗法）により導出する。手法の改良も予定。偏光の取り扱いが重要。