An Algorithm for Greenhouse Gas Retrievals Using Polarization Information Measured by GOSAT TANSO-FTS

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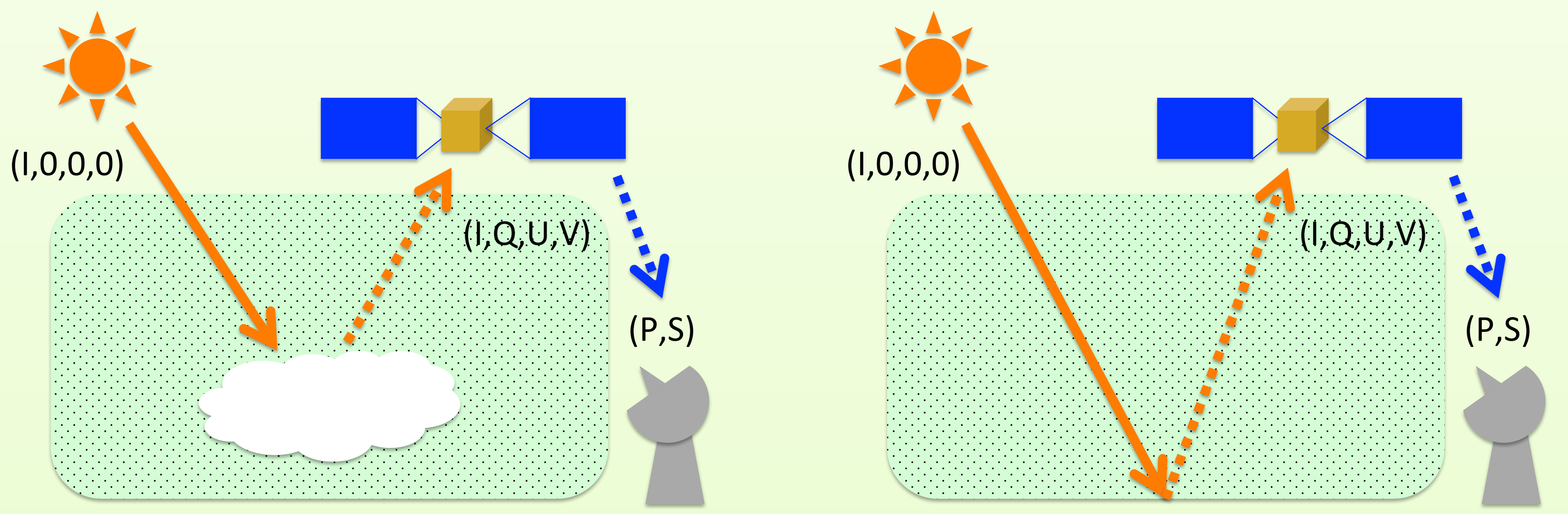
Summary

GOSAT TANS0-FTS acquires two linear polarization spectra, primary (P) and secondary (S), in SWIR, which can be used to correct interference effects of clouds and aerosols on precise retrievals of column-averaged dry air mole fractions of carbon dioxide (XCO_2) and methane (XCH_4). Using a global distribution of aerosols generated by an aerosol transport model SPRINTARS, we analyzed the information content of aerosol vertical profiles which can be extracted from simulated P and S spectra.

1. Introduction



Polarization state of reflected sunlight contains information on clouds and aerosols.

GOSAT TANSO-FTS measures two linear polarizations (P,S) in SWIR, which, in principle, can be used for aerosol correction.

So far, there is no operational algorithm which explicitly uses polarization information.

In reality, reflected sunlight is also polarized by the surface.

The surface polarization must be retrieved simultaneously with other retrieved parameters unless it is known with sufficient accuracy.

__Question__: Can we get more information on aerosols by measuring polarization of reflected sunlight when the surface polarization is not known?

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__Numerical experiments__

2. Method

__Bidirectional Reflection Matrix (BRM) model__

(ad hoc) combination of the BRDF model of Rahman et al. (1993) and the BPDF model of Maignan et al. (2009)

$$\mathbf{R}(\theta_0,\theta_1,\Delta\phi;r,k,g,p)=\frac{r\times h(\theta_0,\theta_1,\Delta\phi;r)}{\left[(\cos\theta_0\cos\theta_1)(\cos\theta_0+\cos\theta_1)\right]^{1-k}}$$

$$\times\begin{pmatrix} a_{11}(\Theta;g) & pa_{12}(\Theta) & 0 & 0 \\ pa_{12}(\Theta) & a_{11}(\Theta;g) & 0 & 0 \\ 0 & 0 & pa_{33}(\Theta) & 0 \\ 0 & 0 & 0 & pa_{33}(\Theta) \end{pmatrix}$$

$\theta_0,\theta_1,\Delta\phi$: Incident, reflected, and relative azimuth angles

r,k,g,p : BRM parameters

h : hot spot correction factor

a_{11} : Henyey-Greenstein function

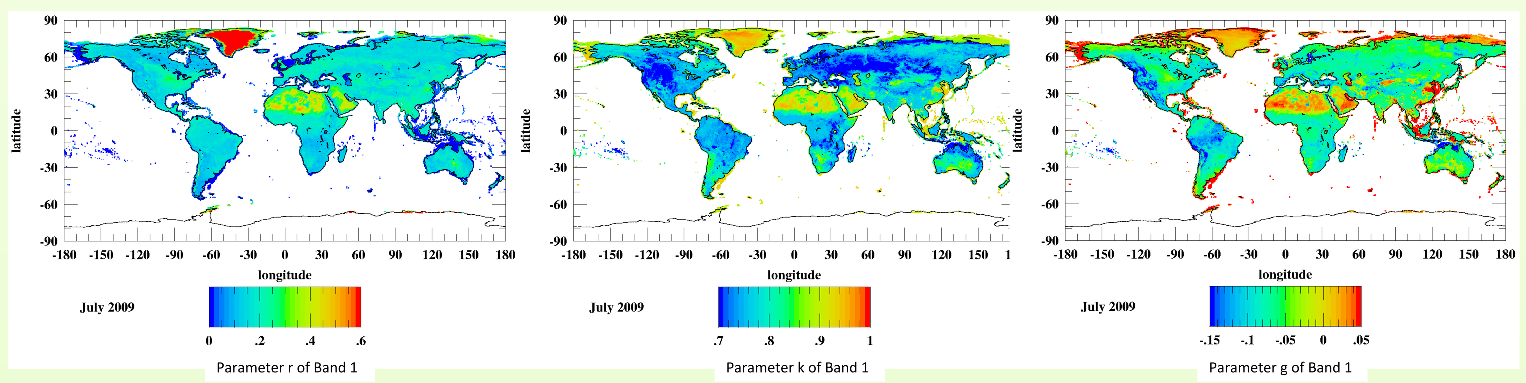
a_{12},a_{33} : Fresnel reflection

Θ : scattering angle

__BRM parameters__

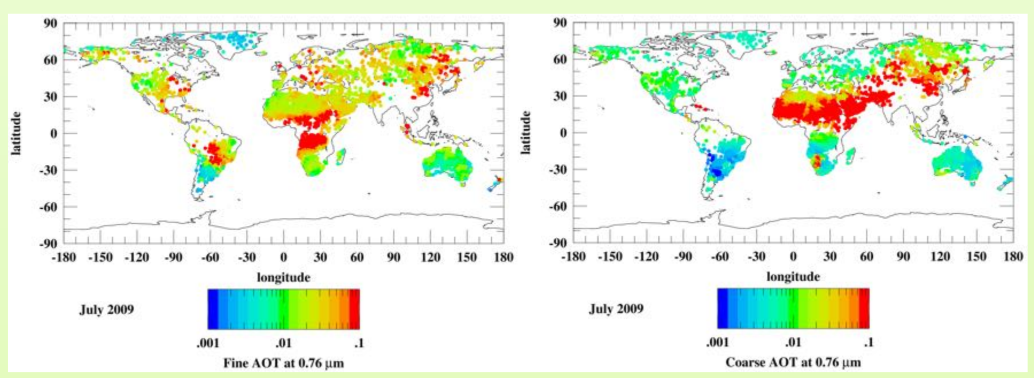
r, k, g : derived from MODIS MCD43C1.5.

p : assumed to be zero.



__Aerosol global distribution__

Generated by SPRINTARS.



Fine aerosols = carbonaceous + sulfate   Coarse aerosols = dust + sea salt

__Retrieved variables__

- Volume mixing ratio of CO_2, CH_4 and H_2O
- Zero level offset
- Chlorophyll fluorescence
- Wavenumber shift
- BRM parameters (r and p)
- Surface pressure
- Temperature shift
- Aerosol vertical profiles (fine and coarse, logarithm of mass mixing ratio)

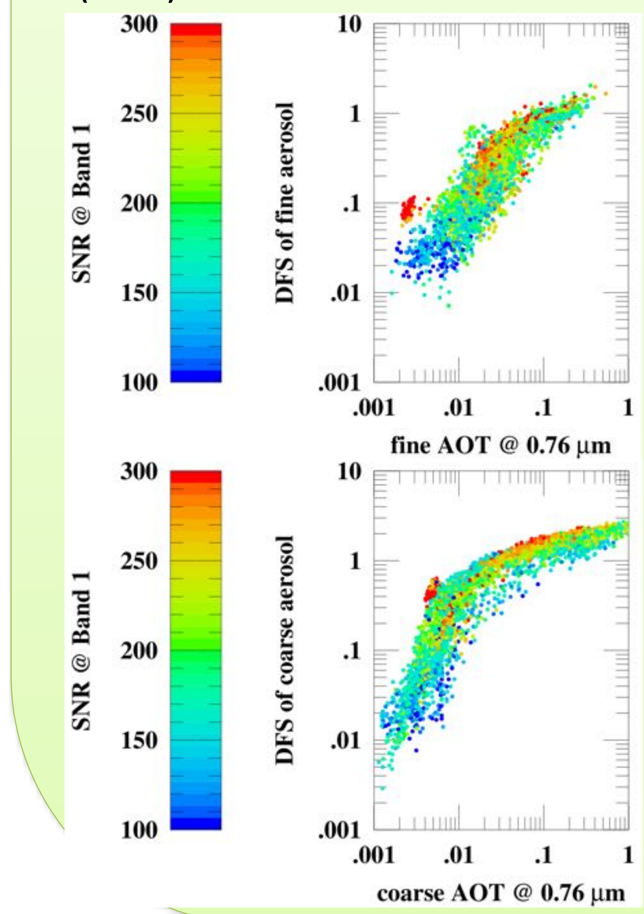
__Wavenumber range [cm^{-1}]__

12950-13200, 6180-6280, 5900-6150, 4800-4900

3. Results

__Case 0:__

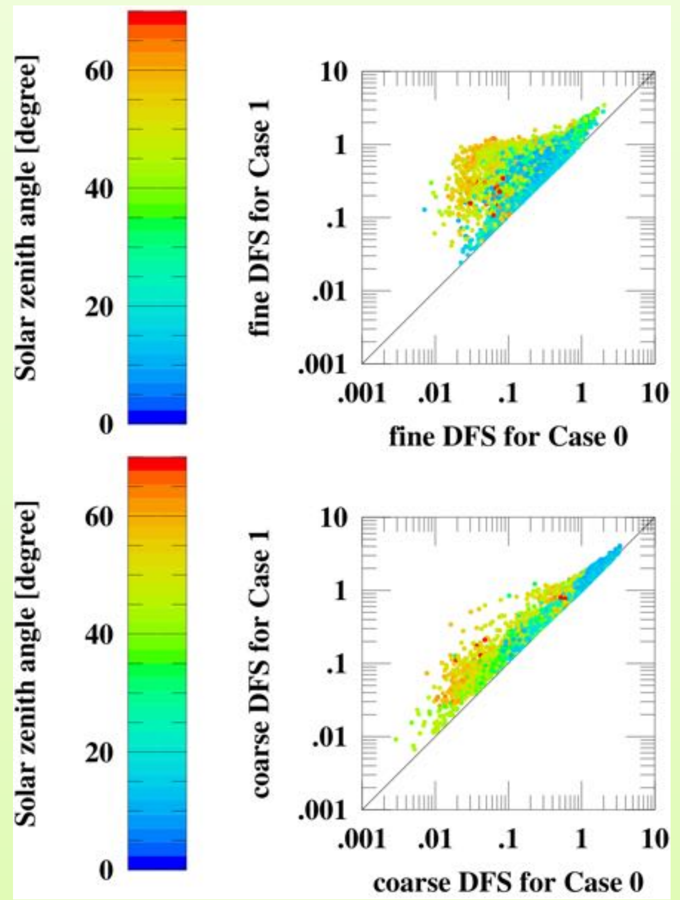
This is a reference case, in which polarization is NOT considered. The degrees of freedom for signal (DFS) for vertical profiles of fine and coarse aerosols are plotted against aerosol optical thickness (AOT).



__Case 1:__

The surface polarization is assumed to be known, though this would not be a realistic assumption.

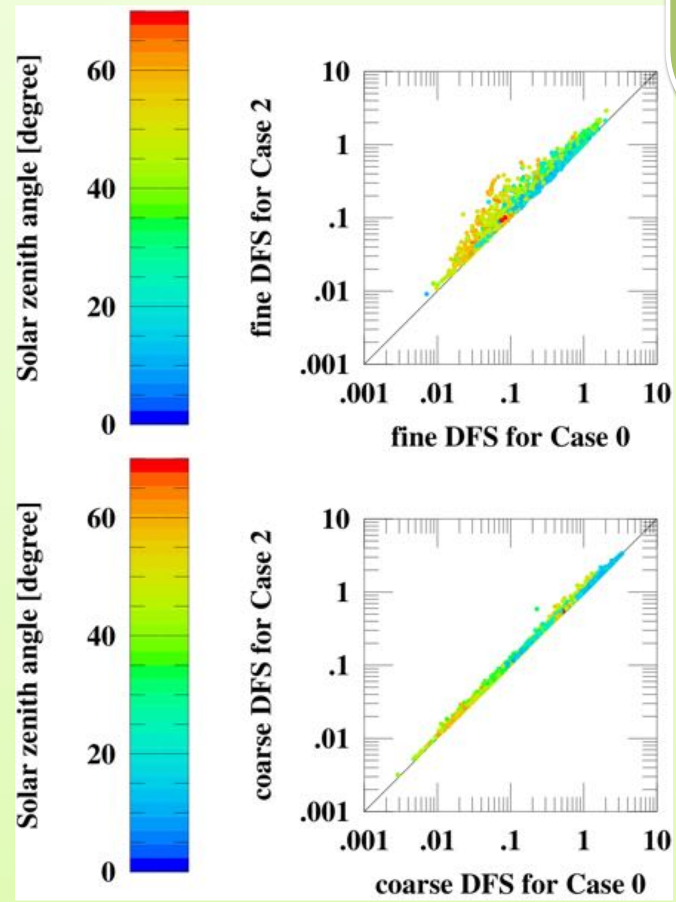
The DFSs for aerosol vertical profiles increase substantially compared to case 0.



__Case 2:__

The surface polarization is retrieved independently at each band.

Only small gains in the DFSs are seen.



Is it possible to get more information on aerosols when the surface polarization is not known?

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The surface polarization is spectrally neutral (Waquet et al. 2009).

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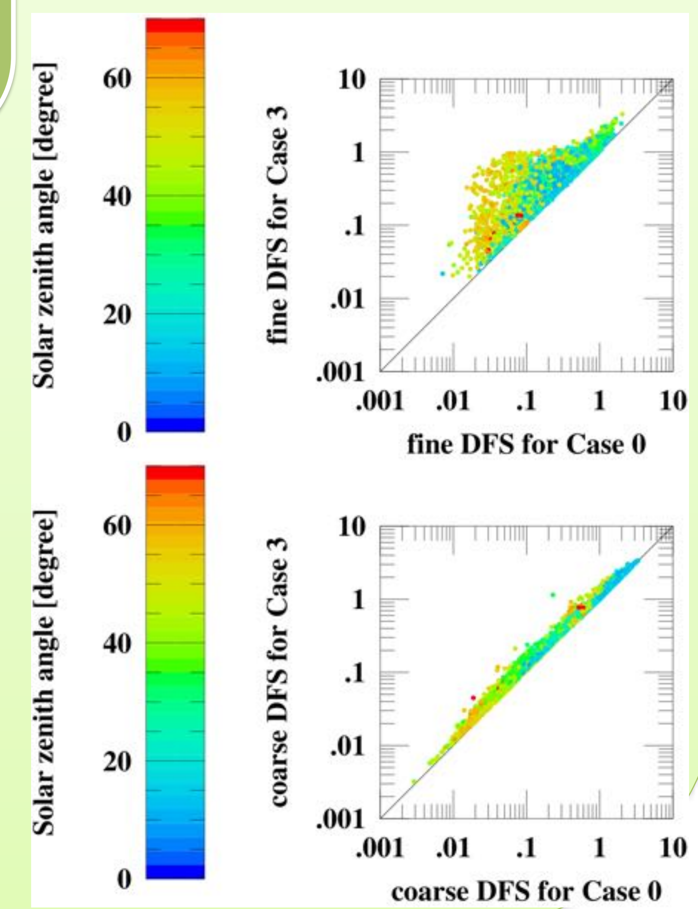
__Case 3:__

The surface polarization is retrieved assuming that the BRM parameter p does not depend on wavelength. Gain in the DFS for fine aerosols is comparable to case 1.



4. Conclusions

- We confirmed that more information on aerosol vertical profiles are obtained by polarization measurements if the surface polarization is known.
- If the surface polarization is not known at all and must be retrieved simultaneously with other retrieved parameters, the benefit of polarization measurements is limited.
- Additional constraint on wavelength dependence of the surface polarization (e.g., spectrally neutral) improves the information content of aerosol vertical profiles.

__Future work:__

Analyses of real GOSAT data with a revised BRM model.

Acknowledgement

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Reference

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