Trends in GOSAT TANSO-FTS radiometric response from L1B data: a work in progress

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Motivation

The retrieval of column carbon dioxide (XCO_2) from GOSAT measurements in the near-infrared requires accurate absolute calibration of each spectral band [1]. Vicarious calibration of the GOSAT sensors has been performed at the Railroad Valley, Nevada site to characterize the radiometric sensitivity [2]. This is a complex exercise, requiring a large investment of resources and is therefore only performed annually. More recently, an analysis of the on-board solar diffuser data was performed [3], which provides a relative estimate of the radiometric degradation since launch. The relative calibration was then married to the absolute calibration to provide the best estimate of decay [4]. However, even the on-board solar diffuser data are measured on an approximately monthly time scale. We hypothesize that an analysis of individual soundings may provide some insight into the radiometric sensitivity of the instrument. With that in mind, we present a preliminary study of trends in select GOSAT TANSO-FTS L1B data fields .

Data set and methodology

L1B data fields, such as signal-to-noise ratio (SNR), subset to particular locations with invariant surface, e.g. deserts, should yield trends related to radiometric degradation of the sensor. A four year time series from TANSO-FTS is now available. The work presented here used JAXA v150151 data, processed via ACOS b3.03, spanning April 2009 to April 2013. Data were screened using the operational ACOS A-band cloud screening [5]. Regional subsets were created using 4°x4° lat/lon boxes in areas of interest, such as deserts and TCCON sites, as well as the Railroad Valley vicarious calibration site. Some examples are shown in Figure 1. The SNR in the Oxygen A-band, weak CO_2 and strong CO_2 bands were analyzed. Only Oxygen-A band results are presented here. See Figure 2.

Figure 1. Google Earth images of some select sites. The center latitude and longitude are indicated by the yellow pushpin, while the search region is given by the black box. The four regions are Egypt (27N, 26E, top left), Arabia (19N, 47E, top right), Railroad Valley (38N, 116W, bottom left) and Lamont (37N, 97W, bottom right).

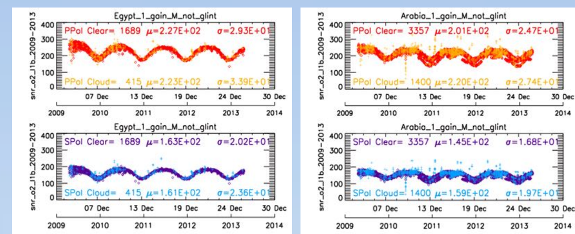

Figure 2: Time series of SNR in Oxygen-A band for P-polarization (top) and S-polarization (bottom) at the Egypt site (left panel) and Arabia site (right panel). Both clear and cloudy soundings and the relevant statistics for each are displayed.

Estimating radiometric degradation and comparison to Yoshida estimates

Each time series was deseasonalized by removing the monthly median value from each data point.

A non-linear least squares routine (with apriori constraint) was used to fit the deseasonalized time series using the following functional form;

$$Y(t) = D + E \exp[-(t-t_0)/T],$$

where D gives the asymptotic decay value, E is the dynamic range of the decay, T is days required for 66% of the decay to occur and t_0 is defined as the day of GOSAT launch (Jan 23, 2009).

The radiometric degradation factor (RDF) for a given variable at any time t (days since launch) is determined as;

$$RDF(t) = Y(t)/Y(t=0).$$

Comparison of the estimated RDF's were made to the degradation estimates given by the Yoshida, et al., on-board solar diffuser analysis as seen in Fig 3.

Summary of results

The table shows a summary of RDF's in the Oxygen-A band P polarization at a number of sites corresponding to the times of GOSAT vicarious calibrations in 2009 and 2013. Typically the fit to the Oxygen-A band SNR greatly over-estimates the degradation relative to the Yoshida estimate.

Site	Latitude	Longitude	RDF (June 2009)	Yoshida (June, 2009)	Delta	RDF (June 2012)	Yoshida (June, 2012)	Delta
Arabia	18.88N	46.76E	0.942	0.976	**-0.034**	0.841	0.941	**-0.099**
Egypt	27.12N	26.10E	0.965	0.976	**-0.011**	0.901	0.941	**-0.040**
RRV	38.50N	115.69W	0.926	0.976	**-0.051**	0.812	0.941	**-0.129**
Lamont	36.60N	97.49W	0.945	0.976	**-0.032**	0.818	0.941	**-0.123**

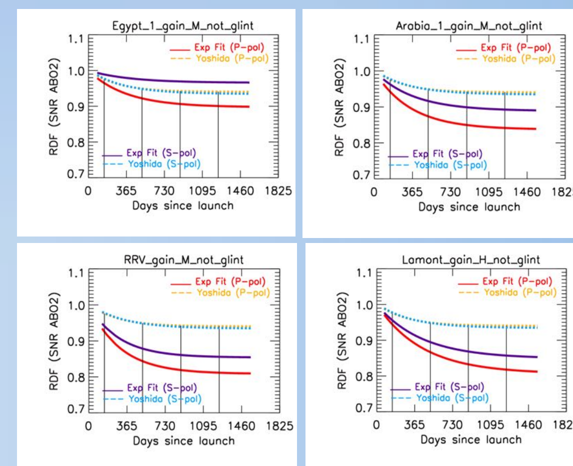

Figure 3: Radiometric degradation factors (RDF) determined from the Oxygen-A band SNR for Egypt (top left), Arabia (top right), Railroad Valley (bottom left) and Lamont (bottom right). Shown are both the P-polarization (red) and S-polarization (purple) as solid lines, with Yoshida fits as dashed lines. Vertical black lines correspond to RRV vicarious calibration campaigns.

Future work

<u>The work presented here is a preliminary analysis. At this time we are unable to draw any firm conclusions from the results.</u> There are a number of issues that will be addressed in the future. 1.) A better filtering scheme needs to be implemented as at some sights there are numerous clear-sky soundings with large deviation from the mean. 2.) It was determined that the exponential fit can be unstable, thus requiring implementation of an apriori to constrain the fit. The fit itself is somewhat sensitive to the selection of apriori, so further investigation is necessary. 3.) What are the physical mechanisms driving the observed trends in SNR and why do the trends not agree with the Yoshida estimates? 4.) Use of SNR may be problematic. A better quantity is the signal level over some small spectral window, normalized by air mass factor. Are there other data fields in the L1b file that may provide insight into the radiometric sensitivity?

References

[1] O'Dell, et al, The ACOS CO2 retrieval algorithm – Part 1: Description and validation against synthetic observations, *AMT* , 2012.

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[5] Taylor, et al., Comparison of cloud-screening methods applied to GOSAT near-infrared spectra, *IEEE TGRS*, 2012.