1. Introduction
The NIES GOSAT Project has produced the FTS SWIR Level 2 products (hereinafter referred to as “SWIR L2 product”) from the FTS Level 1B products (hereinafter referred to as “FTS L1B data”) provided by JAXA. The SWIR L2 products (V02.80) with the FTS L1B data (V210.210) as the input for the entire observation period since April 23, 2009 have been released to General Users (GU). Since the SWIR L2 products (V02.80) are minor upgraded, now we start to release their products as the SWIR L2 products (V02.81) to GU. The entire observation period since April 23, 2009 will be covered. Accordingly, the production of the SWIR L2 products (V02.80) had finished on August 31, 2019.

In the FTS SWIR Level 2 processing (hereafter referred to as “SWIR L2 processing”) (V02.81) to produce the SWIR L2 products (V02.81), the FTS L1B data as input product is the same and there is no major change of the processing algorithm itself from the SWIR L2 processing (V02.80). The primary change is that the thresholds for the pre-screening determination items have been revised. As for the details on the SWIR L2 processing algorithm and SWIR L2 processing (V02.80), please refer to “Algorithm Theoretical Basis Document (ATBD) for CO₂, CH₄ and H₂O Column Amounts Retrieval from GOSAT TANSO–FTS SWIR (Version 2.0)” (hereinafter referred to as “ATBD”) and “Appendix FTS SWIR Level 2 Products (V02.80)” (hereinafter referred to as “Appendix”).

2. Pre-screening
Among “Pre-screening” redefined as the filtering of high quality FTS L1B data capable of retrieval processing (see Appendix Chapter A4, pp.A2–A3), we have revised the thresholds for the following 2 determination items.

(1) CAI Radiance Determination (see ATBD Section 3.5, pp.35–36)
(2) Spectrum Quality Determination (see ATBD Section 3.9, pp.38–39)
2.1 CAI Radiance Determination

In “CAI Radiance Determination” (see ATBD Section 3.5, pp.35–36), the vicarious calibration coefficients, applied when calculating the mean value and standard deviation of the CAI Band 1 radiance within the FTS’s FOV (ocean), have been changed (Table 2.1-1). Furthermore, the threshold line has been revised using long-term real data and considered the temporal variation of the CAI sensor.

**SWIR L2 processing (V02.80)**

- CAI vicarious calibration coefficients (Band 1)
  - Slope and offset values in column V02.80 of Table 2.1-1
- Threshold line

\[ I_{\text{SD}} = 0.0125 \times I_{\text{Mean}} - 0.4 \]

**SWIR L2 processing (V02.81)**

- CAI vicarious calibration coefficients (Band 1)
  - Slope and offset values in column V02.81 of Table 2.1-1
- Threshold line

\[ I_{\text{SD}} = (0.006 \times I_{\text{Mean}} + 0.25) + 0.00003 \times (JD - JD_0) \]

- \( I_{\text{Mean}} \): Mean CAI Band 1 radiance within FTS’s FOV (ocean)
- \( I_{\text{SD}} \): Standard deviation of CAI Band 1 radiance within FTS’s FOV (ocean)
- \( JD \): Observation date (Julian Day)
- \( JD_0 \): Standard observation date (Julian Day on January 24, 2013)

Examples of the scatter plots of the mean value and standard deviation of the CAI Band 1 radiance within the FTS’s FOV (ocean) before pre-screening in the SWIR L2 processing (V02.80 and V02.81) are shown in Figure 2.1-1. The color of each dot (FTS’s scan) represents the CAI cloud pixel ratio within the FTS’s FOV (red dot is cloud-free), which is calculated by the following equation:

\[
\text{CAI cloud pixel ratio} [\%] = \frac{\text{Number of CAI cloud pixels within FTS’s FOV}}{\text{Number of CAI pixels within FTS’s FOV}} \times 100 ,
\]

where the number of CAI cloud pixels within the FTS’s FOV is the sum of the number of confident cloudy (integrated CCL between 0.00–0.15) pixels and probably cloudy (integrated CCL between 0.15–0.33) pixels. The each green line represents the threshold line, and it is the threshold line on the 16th of each month for the SWIR L2 processing (V02.81). The dots below the threshold line are determined as cloud-free (Pass) in “CAI Radiance Determination”. Note that the blue dots are determined as cloudy (Fail) in “CAI Cloud Determination” (see ATBD Section 3.4, pp.32–35).
### Table 2.1–1: CAI vicarious calibration coefficients (Band 1)

<table>
<thead>
<tr>
<th>Applicable period</th>
<th>V02.80</th>
<th>V02.81</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Slope</td>
<td>Offset</td>
</tr>
<tr>
<td>April 23, 2009 ~ September 30, 2009</td>
<td>1.038</td>
<td>8.122</td>
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<tr>
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<td>1.099</td>
<td>4.600</td>
</tr>
<tr>
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<td>1.036</td>
<td>8.355</td>
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<tr>
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<td>1.095</td>
<td>4.901</td>
</tr>
<tr>
<td>October 1, 2010 ~ January 31, 2011</td>
<td>1.261</td>
<td>-3.411</td>
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<tr>
<td>February 1, 2011 ~ May 31, 2011</td>
<td>1.205</td>
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<td>1.203</td>
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<td>October 1, 2011 ~ January 31, 2012</td>
<td>1.212</td>
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<td>February 1, 2012 ~ May 31, 2012</td>
<td>1.213</td>
<td>0.000</td>
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<td>June 1, 2012 ~ September 30, 2012</td>
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<tr>
<td>October 1, 2012 ~ January 31, 2013</td>
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<td>June 1, 2013 ~ September 30, 2013</td>
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<td>0.000</td>
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<tr>
<td>October 1, 2013 ~ January 31, 2014</td>
<td>1.110</td>
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<td>1.359</td>
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<td>1.336</td>
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<td>April 1, 2019 ~ July 31, 2019</td>
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<tr>
<td>August 1, 2019 ~ November 30, 2019</td>
<td>1.354</td>
<td>0.000</td>
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</table>

Note: Before March 31, 2017, the coefficients obtained from non-unified evaluation approaches had been applied in the SWIR L2 processing (V02.80); however, in the SWIR L2 processing (V02.81), the coefficients obtained from the same unified evaluation approach as after April 1, 2017 have been applied.
Figure 2.1-1: Scatter plots of mean value and standard deviation of CAI Band 1 radiance within FTS’s FOV (ocean) before pre-screening in SWIR L2 processing (V02.80 and V02.81).
Figure 2.1-1: Scatter plots of mean value and standard deviation of CAI Band 1 radiance within FTS’s FOV (ocean) before pre-screening in SWIR L2 processing (V02.80 and V02.81) (Continued).

- 5 -
2.2 Spectrum Quality Determination

In “Spectrum Quality Determination” (see ATBD Section 3.9, pp. 38–39), the threshold values of all quality determinations for the averages and standard deviations (real and imaginary part) of the out-of-band spectra have been revised again using longer-term real data (Table 2.2–1). As for the threshold values for the spectrum quality determination of the SWIR L2 processing (V02.80), please refer to Appendix Section A4.2, pp. A3–A4 Table A4.2–1.

Table 2.2–1: Threshold values for the spectrum quality determination
(Upper/lower threshold values for low/high-wavenumber sides)

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<tr>
<th></th>
<th>Band 1P</th>
<th>Band 1S</th>
<th>Band 2P</th>
<th>Band 2S</th>
<th>Band 3P</th>
<th>Band 3S</th>
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<tr>
<td>T&lt;sub&gt;UL1&lt;/sub&gt;</td>
<td>(Gain H/M)</td>
<td>0.048</td>
<td>0.048</td>
<td>0.065</td>
<td>0.064</td>
<td>0.065</td>
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<tr>
<td></td>
<td>(Gain H)</td>
<td>0.054</td>
<td>0.054</td>
<td>0.065</td>
<td>0.064</td>
<td>0.059</td>
</tr>
<tr>
<td></td>
<td>(Gain M)</td>
<td>0.048</td>
<td>0.048</td>
<td>0.065</td>
<td>0.064</td>
<td>0.065</td>
</tr>
<tr>
<td>T&lt;sub&gt;LL2&lt;/sub&gt;</td>
<td>(Gain H)</td>
<td>−6.04</td>
<td>−5.76</td>
<td>−7.23</td>
<td>−7.14</td>
<td>−7.19</td>
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<tr>
<td></td>
<td>(Gain M)</td>
<td>−6.02</td>
<td>−5.74</td>
<td>−7.20</td>
<td>−7.10</td>
<td>−6.95</td>
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<tr>
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<td>(Gain H)</td>
<td>−6.15</td>
<td>−5.99</td>
<td>−6.93</td>
<td>−6.90</td>
<td>−6.98</td>
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<tr>
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<td>(Gain M)</td>
<td>−6.17</td>
<td>−6.00</td>
<td>−6.90</td>
<td>−6.87</td>
<td>−6.91</td>
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<tr>
<td>T&lt;sub&gt;LL3&lt;/sub&gt;</td>
<td>(Gain H)</td>
<td>−5.11</td>
<td>−4.89</td>
<td>−5.36</td>
<td>−5.32</td>
<td>−5.56</td>
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<td>(Gain M)</td>
<td>−5.18</td>
<td>−4.93</td>
<td>−5.32</td>
<td>−5.28</td>
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<tr>
<td>T&lt;sub&gt;UL3&lt;/sub&gt;</td>
<td>(Gain H)</td>
<td>−5.38</td>
<td>−5.31</td>
<td>−5.78</td>
<td>−5.75</td>
<td>−5.99</td>
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<tr>
<td></td>
<td>(Gain M)</td>
<td>−5.37</td>
<td>−5.30</td>
<td>−5.68</td>
<td>−5.66</td>
<td>−6.07</td>
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<tr>
<td>T&lt;sub&gt;UL4&lt;/sub&gt;</td>
<td>(Gain H)</td>
<td>−4.74</td>
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<td>(Gain M)</td>
<td>−4.70</td>
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<td>−4.93</td>
<td>−4.81</td>
<td>−4.75</td>
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<tr>
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<td>(Gain H)</td>
<td>−5.08</td>
<td>−4.94</td>
<td>−5.35</td>
<td>−5.27</td>
<td>−5.34</td>
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<td>(Gain M)</td>
<td>−5.08</td>
<td>−4.93</td>
<td>−5.32</td>
<td>−5.25</td>
<td>−5.34</td>
</tr>
</tbody>
</table>

Table 2.2–1: Threshold values for the spectrum quality determination
(Upper/lower threshold values for low/high-wavenumber sides)
**Acronyms**

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>CAI</td>
<td>Cloud and Aerosol Imager</td>
</tr>
<tr>
<td>CCL</td>
<td>Clear-sky Confidence Level</td>
</tr>
<tr>
<td>FOV</td>
<td>Field Of View</td>
</tr>
<tr>
<td>FTS</td>
<td>Fourier Transform Spectrometer</td>
</tr>
<tr>
<td>GOSAT</td>
<td>Greenhouse gases Observing SATellite</td>
</tr>
<tr>
<td>JAXA</td>
<td>Japan Aerospace Exploration Agency</td>
</tr>
<tr>
<td>NIES</td>
<td>National Institute for Environmental Studies</td>
</tr>
<tr>
<td>SD</td>
<td>Standard Deviation</td>
</tr>
<tr>
<td>SWIR</td>
<td>Short-Wavelength Infrared</td>
</tr>
<tr>
<td>TANSO</td>
<td>Thermal And Near-infrared Sensor for carbon Observation</td>
</tr>
</tbody>
</table>
Appendix FTS SWIR Level 2 Products (V02.80)

A1. Introduction
The SWIR L2 products (V02.80) were produced with the FTS L1B data (V210.210) as input without using the format conversion tool provided by JAXA.

A2. Input Product
There was no major change of the processing algorithm itself from the SWIR L2 processing (V02.72) in the SWIR L2 processing (V02.80) to produce the SWIR L2 products (V02.80). The primary change was the upgrade of the FTS L1B data as input product.

The details of the major updates for the FTS L1B data related to the SWIR L2 processing are described in the following:

- Update of SWIR radiance conversion table
- Upgrade of Band 1 high gain saturation criteria at high radiance input
- Revision of Band 1 high gain over-correction
- Update of Band 1 phase delay parameter table

A3. Pre-processing
A3.1 Degradation Correction
Since the radiometric degradation model corresponding to the FTS L1B data (V201.202), same as the SWIR L2 processing (V02.72), has been used in “Degradation Correction” (see ATBD Section 2.4, p.18), the radiometric degradation correction corresponding to the FTS L1B data (V210.210) was performed by changing (updating) the solar irradiance baseline correction factor.

A3.2 Polarization Synthesis Process
The radiance conversion table (provided by JAXA) referred to in “Polarization Synthesis Process” (see ATBD Section 2.6, pp.20–29) was changed (updated).
A4. Pre-screening

We redefined the filtering of high quality FTS L1B data capable of retrieval processing as pre-screening and set the following eight determination items from “Data Screening” (see ATBD Chapter 3, pp.30–39) and “Quality Check Process” (see ATBD Section 9.2, pp.71–72).

1. L1 Quality Determination (see ATBD Section 3.1, pp.30–31)
2. Solar Zenith Angle Determination (see ATBD Section 3.2, p.31)
3. CAI Cloud Determination (see ATBD Section 3.4, pp.32–35)
4. CAI Radiance Determination (see ATBD Section 3.5, pp.35–36)
5. 2 µm Band Scattering Material Determination (see ATBD Section 3.6, pp.36–37)
6. Spectrum Quality Determination (see ATBD Section 3.9, pp.38–39)
7. O₂ Sub-band SNR Determination (see ATBD Section 9.2 (1), p.71)
8. Land Fraction/Ocean Region Determination (see ATBD Section 9.2 (8), p.72)

A4.1 L1 Quality Determination

In “L1 Quality Evaluation” (see ATBD Section 3.1, pp.30–31), the following conditions were added to exclude from the determination target scans before determining the quality.

1. “Satellite Attitude Control Mode” is set as (2), meaning the Moon Pointing Mode
   Satellite Attitude Control Mode
   /exposureAttribute/pointAttribute/satellite/satelliteAttitudeStabilityFlag
2. “Actuated Pointing Mirror Flag” and “Optical Path Selector Flag” are inconsistent
   Actuated Pointing Mirror Flag
   /exposureAttribute/pointAttribute/radiometricCorrectionInfo/actuatedPointingMirrorFlag
   Optical Path Selector Flag
   /exposureAttribute/pointAttribute/RadiometricCorrectionInfo/opticalPathSelectorFlag

A4.2 Spectrum Quality Determination

In “Spectrum Quality Determination” (see ATBD Section 3.9, pp.38–39), lower limit values were added to the threshold values of quality determination for the average (real part) of the out-of-band spectrum. Furthermore, the threshold values of all quality determinations for the averages and standard deviations (real and imaginary part) of the out-of-band spectra were revised (Table A4.2–1).
SWIR L2 processing (V02.72)
Quality determination for average (real part $R_{\text{AVG}}$) of out-of-band spectrum

$$\log_{10}(R_{\text{AVG}}) \leq T_{UL2}$$

SWIR L2 processing (V02.80)
Quality determination for average (real part $R_{\text{AVG}}$) of out-of-band spectrum

$$T_{LL2} \leq \log_{10}(R_{\text{AVG}}) \leq T_{UL2}$$

Table A4.2-1: Threshold values for the spectrum quality determination
(Upper/lower threshold values for low/high-wavenumber sides)

<table>
<thead>
<tr>
<th></th>
<th>Band 1P</th>
<th>Band 1S</th>
<th>Band 2P</th>
<th>Band 2S</th>
<th>Band 3P</th>
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<td>$T_{UL1}$ (Gain H/M)</td>
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<td>0.050</td>
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<td>0.060</td>
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</table>
A5. A Priori Information

The atmospheric tracer transport model used as *a priori* information in “A Priori Information of Gas Concentration” (see ATBD Section 6.4, pp.61–62) was changed (updated). The variance and covariance matrices were created anew as well.

**SWIR L2 processing (V02.72)**
* A priori information: NIES Transport Model (NIES05)
* Variance and covariance matrices: Created in 2009

**SWIR L2 processing (V02.80)**
* A priori information: NIES Transport Model (NIES05) nudging version
* Variance and covariance matrices: Created in 2016

A6. Post-screening

We redefined the screening of high quality retrieval results as post-screening and set the following seven determination items from “Quality Check Process” (see ATBD Section 9.2, pp.71–72).

1. Iteration Number Determination
2. DFS (CO₂/CH₄/H₂O) Determination* (see ATBD Section 9.2 (2), p.71)
3. MSR (O₂/CO₂/CH₄/SCO₂ Sub-bands) Determination* (see ATBD Section 9.2 (3), p.71)
4. Retrieved AOT (1.6 µm) Determination* (see ATBD Section 9.2 (4), p.71)
5. Blended Albedo Determination (see ATBD Section 9.2 (5), p.72)
6. Deviation of Retrieved Surface Pressure Determination (see ATBD Section 9.2 (6), p.72)
7. Retrieved Ocean Wind Speed Determination (see ATBD Section 9.2 (7), p.72)
* Items with different criteria for standard (GU)/research (RA) products

A7. Product Format

The datasets not used in pre-screening were deleted and the dataset to be used in the bias-correction processing was added.

Deleted datasets
- Terrain roughness screening
  /scanAttribute/qualityInformation/roughTerrainSurfaceScreening
- High altitude aerosol screening
  /scanAttribute/qualityInformation/highAltitudeAerosolScreening
- TIR cloud screening
  /scanAttribute/qualityInformation/TIRCloudScreening

Added dataset
- Air mass
  /Data/geolocation/airMass
Additionally, the following datasets were changed from the sub-datasets for RA users to the datasets for all users.

Surface albedos retrieved simultaneously
/Data/auxiliaryParameter/surfaceAlbedo
Number of retrieved albedo grid
/ancillary/FTSL2DataInformation/numRetAlb
Index for retrieved albedo grid
/ancillary/FTSL2DataInformation/indxRetAlb
Wavenumber for retrieved albedo grid
/ancillary/FTSL2DataInformation/wnRetAlb