



Assessing the Effect of HITRAN Updates on Cross-Platform Calibration and Validation for Satellite-Based GHG Retrievals

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Objective of This Work



Goal

Validation of multi-GHG satellite sensors using a radiative transfer model

- Approach
 - Forward calculations using RRV surface reflectances
 - Comparison with satellite spectra

Evaluation based on:

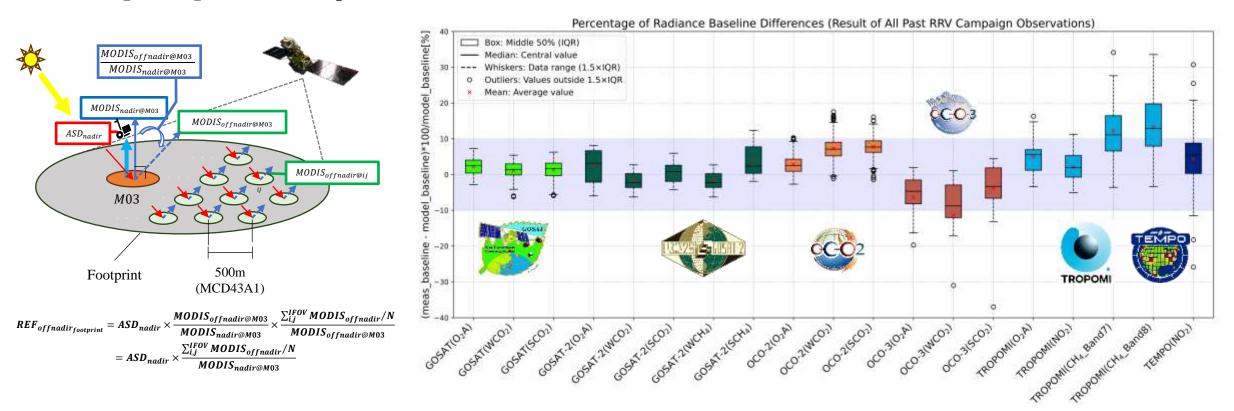
- 1. Spectral baseline agreement (AGU24)
- 2. Absorption line agreement (This presentation)
- Key Focus of This Work
 - HITRAN 2012, 2020, and 2020+ databases were used in the forward calculations Note: HITRAN 2020+ is a "preliminary version" based on HITRAN 2020, with additional CH₄ lines kindly provided by SAO)
 - Retrievals were performed to assess the impact of these line parameters



Baseline comparison (AGU24 presentation Recap)



- Surface reflectance was measured in the **nadir direction at Railroad Valley (RRV).**
- The MODIS BRDF product (MCD43A1) was used to estimate off-nadir reflectance for each satellite footprint.
- Forward radiative transfer calculations were conducted using **LIDORT v3.6**.
- The spectral radiance baseline of the simulated spectra was compared with the Level 1B radiance data form each satellite.
- The **top 15th percentile** of spectral radiance was defined as the baseline.



The radiance conversion factors might be one contributing factor.

(Ishida et al. In prep.)



Forward Calculation Setup [CH₄ Absorption line comparison]



Item	Case-1	Case-2
Radiative Transfer Model	LIDORT v3.6 (*NASA/ACOS ' <i>RTRetrievalFramework</i> ' modified by JAXA.)	- (Same as the left)
Instrument Line Shape Function	Data published on the GOSAT-2 Product Archive website https://prdct.gosat-2.nies.go.jp/documents/documents.html.en	- (Same as the left)
Surface Reflectance		
Reflectance in the nadir direction	RRV in-situ measurement reflectance in the nadir direction	- (Same as the left)
Nadir to Off-nadir conversion (BRDF)	MODIS (MCD43A1)	- (Same as the left)
Meteorological Data	NCEP North American Regional Reanalysis (NARR)	- (Same as the left)
Aerosol AOT	AERONET (Using AOT at RRV)	- (Same as the left)
Line Parameter		
O_2A	ABSCO v5.2	- (Same as the left)
H_2O	HITRAN2012 (AER line parameter v3.7)	- (Same as the left)
CO_2	HITRAN2012 (AER line parameter v3.7)	- (Same as the left)
CH ₄	HITRAN2020	HITRAN2020+
CO	HITRAN2012 (AER line parameter v3.7)	- (Same as the left)
N_2O	HITRAN2012 (AER line parameter v3.7)	- (Same as the left)
Gas A priori	AJAX (long-term corrected VMR)	- (Same as the left)

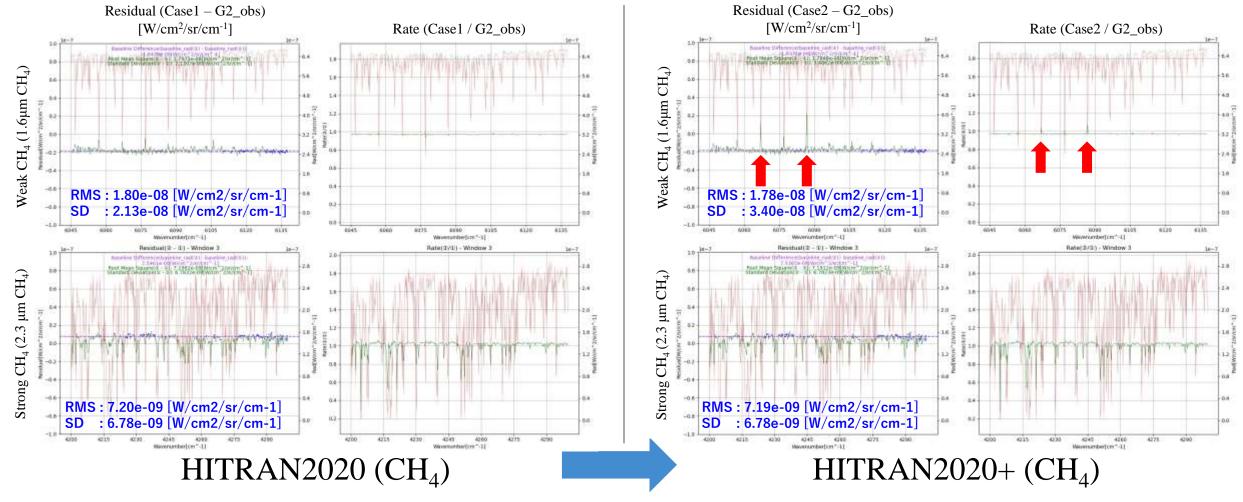


Comparison of CH₄ line parameters between HITRAN2020 and HITRAN2020+



- CH₄ line parameters were updated from HITRAN2020 to HITRAN2020+
- Other gases based on HITRAN2012 data

Blue dot show the baseline.(Top 15 percentile of radiance)

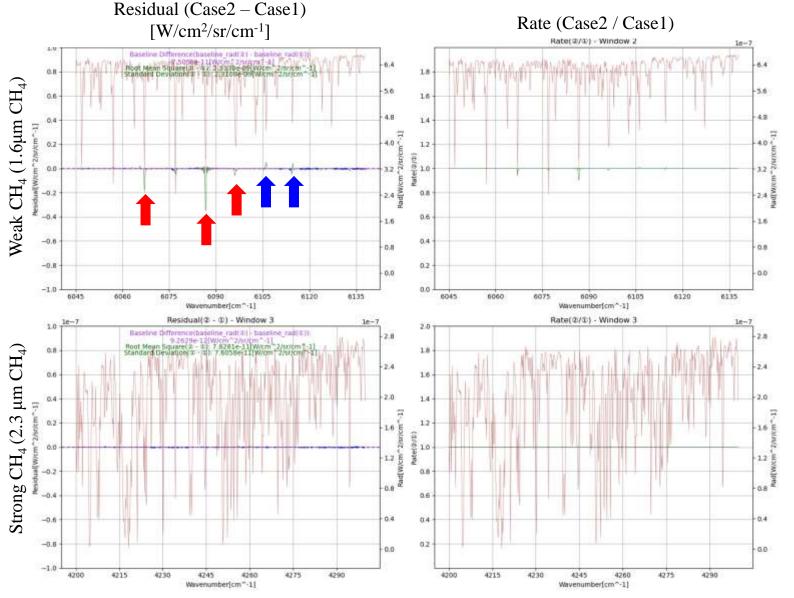


HITRAN2020+ CH₄ line parameters led to visibly deeper absorption lines in the weak CH₄ band.



Model-to-model comparison using HITRAN2020+ and HITRAN2020





• Significant deepening of CH₄ absorption lines in the weak bands with HITRAN 2020+.

(Red Arrow)

• Slight shallowing of some lines in specific wavenumber regions.

(Blue Arrow)





XCH4 Retrieval Setup (6 TCCON sites)



	Item	Previous Setting	Current Setting (This Presentation)
Radiative Transfer Model		LIDORT v3.6 (*NASA/ACOS ' <i>RTRetrievalFramework</i> ' modified by JAXA.)	- (Same as the left)
Instrument Line Shape Function		Data published on the GOSAT-2 Product Archive website https://prdct.gosat-2.nies.go.jp/documents/documents.html.en	- (Same as the left)
Meteorological Data		NCEP/DOE Reanalysis 2	- (Same as the left)
Line Parameter			
	O_2A	ABSCO v5.2	- (Same as the left)
	H_2O	HITRAN2012 (AER line parameter v3.7)	HITRAN2020
	CO_2	HITRAN2012 (AER line parameter v3.7)	HITRAN2020
	CH ₄	HITRAN2012 (AER line parameter v3.7)	HITRAN2020 or HITRAN2020+
	CO	HITRAN2012 (AER line parameter v3.7)	HITRAN2020
	N_2O	HITRAN2012 (AER line parameter v3.7)	HITRAN2020
Gas A priori		Carbon Tracker (CT-CH4-2025)	- (Same as the left)
Т	argeted TCCON Stations	Caltech (US) East Trout Lake (CA) Edwards (US) Lauder (NZ) Lamont (US) Saga (JP)	- (Same as the left)







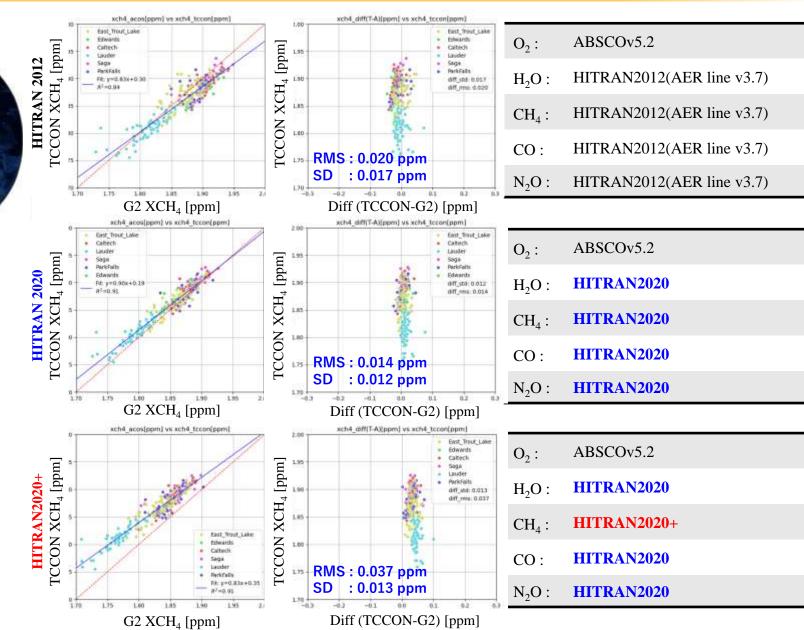
Line parameter update for XCH₄ retrieval [3-band retrieval using O_2A and the weak/strong CH_4 band]





Targeted TCCON Sites

- Caltech (US)
- East Trout Lake (CA)
- Edwards (US)
- Lauder (NZ)
- Lamont (US)
- Saga (JP)
- Rows: HITRAN2012, 2020, 2020+(Only CH₄)
- Columns:
 - Left: TCCON XCH₄ vs. G2 retrieval
 - Right: TCCON XCH₄ vs. Diff(TCCON G2)







Line parameter update for XCH₄ retrieval [2-band retrieval using O₂A and the weak CH₄ bands]



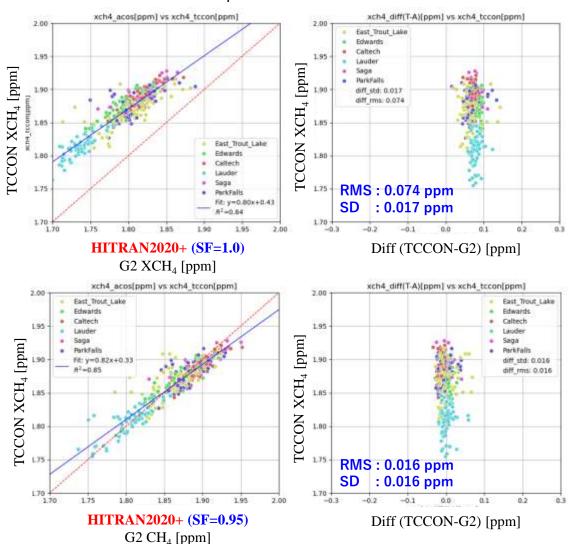
To evaluate the impact of changes in the CH_4 absorption lines in the weak CH_4 band on retrieval results, XCH_4 retrievals were performed using only the O_2 A-band and the weak CH_4 band.

2-band $(O_2A + Weak CH_4)$ Retrieval CH_4 : HITRAN2020+ Scale Factor = 1.0

Adjust the HITRAN line parameter scaling factor for the weak CH_4 band (from 1.00 to 0.95)



Scale Factor = 0.95



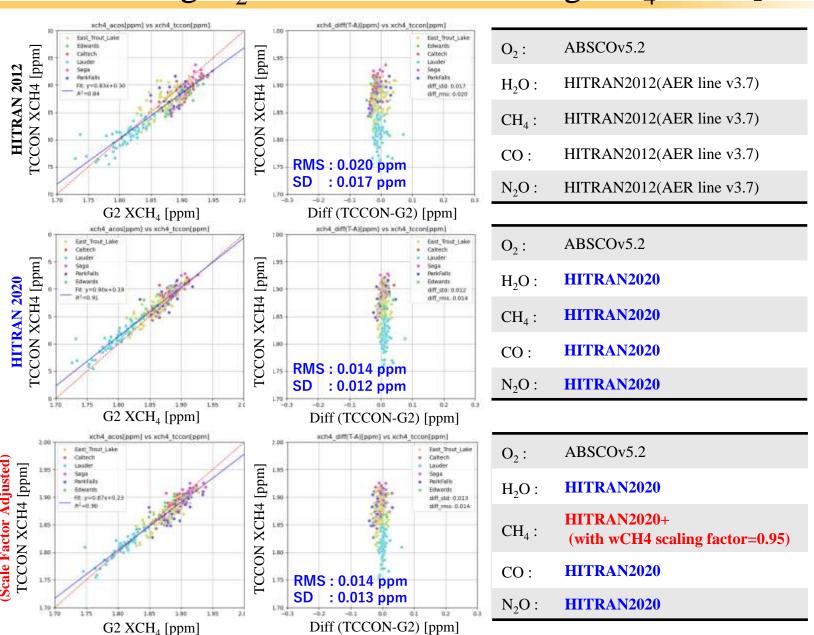


Line parameter update for XCH₄ retrieval [3-band retrieval using O₂A and the weak/strong CH₄ bands]

3-band retrieval with HITRAN2020+ (CH₄, 0.95 scaling for weak CH₄ band) gave comparable results to full HITRAN2020 case.

GOBLEU

Note: The improvement from 2012 to 2020 is mainly due to updated H₂O line parameters.





Summary and Outlook



Forward Calculations

- Development of a tool to compute model spectra using in-situ measured reflectances at RRV for multiple GHG satellites.
- Significantly deeper CH₄ absorption lines in the weak CH₄ (1.6μm) band with HITRAN 2020+.
- These deeper CH₄ absorption lines are not expected to be included in the upcoming HITRAN 2024 release, based on recent updates and communications with SAO.

Retrieval

- Improved performance with HITRAN 2020 compared to HITRAN 2012.
- Deeper CH₄ lines in the weak CH₄ (1.6μm) band with HITRAN 2020+ lead to lower XCH₄ estimates.
- Agreement with TCCON achieved using a scale factor of ~0.95, comparable to HITRAN 2020.

Outlook

- Perform additional validation using the full TCCON dataset and optimize processing parameters for the retrieval code.
- Then, compare the global retrievals with other GOSAT-2 Level 2 products, such as those from NIES, SRON, and Bremen University.
- Retrievals with the upcoming HITRAN 2024 release will be conducted once it becomes available.