

Progress of GOSAT Project in 2012 and



T. Yokota, I. Morino, Y. Yoshida, S. Maksyutov & NIES GOSAT Project members

Center for Global Environmental Research (CGER) & Center for Environmental Measurement & Analysis (CEMA) National Institute for Environmental Studies (NIES), Japan

Contents

Overview of the GOSAT Project in the recent two years
Recent progress
Near future plan
Related presentations @ IWGGMS-9

GOSAT (IBUKI) launched by H-IIA F-15 vehicle on January 23, (Photo by MIES)

| Size | Main body | | 3.7 m x 1.8 m x 2.0 m (Wing Span 13.7m) | | | | |
|-----------|---------------------------------------|--|--|-----------------------|-----|--|--|
| Mass | Total | 1750kg | | | | | |
| Power | Total | 3.7 m x 1.8 m x 2.0 m (Wing Span 13.7m) 1750kg 3.8 KW (EOL) 5 years sun synchronous orbit time 13:00+/-0:15 e 666km tion 98deg at 3 days e H-IIA ule Jan. 23 2009 | | | | | |
| Life Time | | | 5 | years | | | |
| Orbit | sun synchronous orbit | | | | | | |
| | Local time Altitude Inclination | | | 13:0 0 +/-0:15 | | | |
| | | | | 666km | | | |
| | | | and a second | 98deg | han | | |
| | Repeat | 題 | | 3 days | | | |
| Launch | Vehicle | | | H-IIA | | | |
| | Schedule | ; | Jan. 23 2009 | | | | |

TANSO-FTS (Fo<u>urier Trans</u>form Spectrometer)

- SWIR reflected on the
- earth's surface
- FIR radiated from the ground and the
- atmosphere

TANSO onboard GOSAT

TANSO=<u>Thermal And Near</u> infrared <u>Sensor</u> for carbon <u>Observation</u>

TANSO-CAI (Cloud and Aerosol Imager)

Ultraviolet (UV) (0.38 micron), visible (0.67 micron), NIR (0.87 micron), and SWIR (1.6 micron)

(Courtesy of JAXA)

Progress during 2012-2013 (1)



- 2012-2013
 - TANSO-FTS SWIR Level 2 (XCO₂ & XCH₄) (V02.**) data products for all of the past TANSO-FTS L1B data have been reprocessed and released to the researchers and general public.
 - TANSO-CAI Level 3 NDVI (Normalized Difference Vegetation Index) product has been open to general users.
 - GOSAT Level 4A (regional monthly CO₂ fluxes with their uncertainties) and Level 4B (model simulated three dimensional distributions of CO₂ concentrations) data products have been released for the period of June 2009 and May 2010.





SWIR L2 V02 series covers more than 3.8 year.

Operational processing delays 2~3 weeks.

SWIR L2 reprocessing with single-version is planned.

(by Y. Yoshida (NIES))



TANSO-FTS SWIR L2 (V02.**) XCO₂ & XCH₄



Monthly XCO₂ distribution observed by GOSAT



(XCO₂ averaged in each 2.5 degree mesh)

| Monthly Global | Map of the CO2 column | n-averaged volume mi | ixing ratios in 2.5 deg i | by 2.5 deg mesh | | | | | |
|------------------|-----------------------|----------------------|----------------------------|------------------|------------------|----------------------------|------------------|------------------|----|
| | 2010/01 (V02.00) | 2011/01 (V02.11) | 2012/01 (V02.10) | 2013/01 (V02.11) | 2009/07 (V02.00) | 2010/07 (V02.00) | 2011/07 (V02.11) | 2012/07 (V02.11) | |
| Jan. | | | | | | | | | Ju |
| | 2010/02 (V02.00) | 2011/02(V02.11) | 2012/02 (V02.10) | 2013/02 (V02.11) | 2009/08 (V02.00) | 2010/08 (V02.10) | 2011/08 (V02.11) | 2012/08 (V02.11) | |
| Feb. | | | | | | | | | Au |
| | 2010/03 (V02.00) | 2011/03 (V02.11) | 2012/03 (V02.10) | 2013/03 (V02.11) | 2009/09 (V02.00) | 2010/09 (V02.10) | 2011/09 (V02.11) | 2012/09 (V02.11) | |
| Mar. | | | 1. Sec. | | | | | | Se |
| | 2010/04 (V02.00) | 2011/04 (V02.11) | 2012/04(V02.10) | 2013/04 (V02.11) | 2009/10 (V02.00) | 2010/10 (V02.10) | 2011/10 (V02.11) | 2012/10 (V02.11) | |
| Apr. | | | | | | | | | Oc |
| | 2010/05 (V02.00) | 2011/05 (V02.11) | 2012/05 (V02.10) | | 2009/11(V02.00) | 2010/11 (V02.10) | 2011/11 (V02.11) | 2012/11 (V02.11) | |
| Мау | | | | | | | | | No |
| 2009/06 (V02.00) | 2010/06 (V02.00) | 2011/06 (V02.11) | 2012/06 (V02.108/02.11) | | 2009/12 (V02.00) | 2010/12 (V02.10&V02.11) | 2011/12 (V02.10) | 2012/12 (V02.11) | |
| | | | | Jun. | | | | | De |
| 2009 | 2010 | 2011 | 2012 | 2013 | 2009 | 2010 | 2011 | 2012 | |

Monthly XCH₄ distribution observed by GOSAT



(XCH₄ averaged in each 2.5 degree mesh)



Monthly global map of XCO₂ and XCH₄ (V02.**) from TANSO-FTS SWIR data



XA CA

Greenhouse gase





Data validation activities have conducted by worldwide research groups

- Column concentrations of CO₂ and CH₄ have been retrieved by several groups (institutes and universities) in the world.
- These data are validated with TCCON FTS data and/or airplane data.
- Present GOSAT XCO₂ data quality is within -0.3% bias and 0.5% variation.



Data validation scheme



SWIR L2 V02.** Algorithm & Validation papers

Atmos. Meas. Tech. Discuss., 6, 949–988, 2013 www.atmos-meas-tech-discuss.net/6/949/2013/ doi:10.5194/amtd-6-949-2013 @ Author(s) 2013. CC Attribution 3.0 License.



This discussion paper rishs been under hivinw for the journel Atmospheric Measurement Techniques (AMT). Prease refer to the consequenting final paper in AMT it available

Improvement of the retrieval algorithm for GOSAT SWIR XCO₂ and XCH₄ and their validation using TCCON data

Y. Yoshida¹, N. Kikuchi¹, I. Morino¹, O. Uchino¹, S. Oshchepkov¹, A. Bril¹, T. Saekl¹, N. Schutgens^{2,*}, G. C. Toon³, D. Wunch⁴, C. M. Roehl⁴, P. O. Wennberg⁴, D. W. T. Griffith⁵, N. M. Deutscher^{5,6}, T. Warneke⁶, J. Notholt⁶, J. Robinson⁷, V. Sherlock⁷, B. Connor⁸, M. Rettinger⁹, R. Sussmann⁹, P. Ahonen¹⁰, P. Heikkinen¹⁰, E. Kyrö¹⁰, and T. Yokota¹

¹National Institute for Environmental Studies, 16-2 Onogawa, Tsukuba 305-8506, Japan ²Atmosphere and Ocean Research Institute, University of Tokyo, 5-1-5 Kashiwanoha, Kashiwa 277-8568, Japan

³Jet Propulsion Laboratory, California Institute for Technology, 4800 Oak Grove Drive, Pasadena, CA, 91109-8099, USA

California Institute for Technology, Pasadena, CA, 91125-2100, USA

⁵Center for Atmospheric Chemistry, University of Wollongong,

New South Wales 2522, Australia

⁶Institute of Environmental Physics, University of Bremen, 28334 Bremen, Germany ⁷National Institute of Water and Atmospheric Research, Wellington, New Zealand

949

Improvement of the retrieval algorithm for GOSAT SWIR XCO₂ and XCH₄ Y. Yoshida et al Title Page Abstract Introduction Conclusions References Tables Figures

AMTD

6.949-988.2013



Interactive Discussion

@ 0



Greenhouse gases CGER Observing SATellite SWIR L2 V02.** Algorithm & Validation papers

Altrice, Massa Tech, Discuss., 6, 949-088, 2013 ware affrest-mass lach-discuss net/\$/948(2015) dx105106/art668-049-0013 © Authoritei 2013. CC Atelbution 3.0 Linemee.



Improvement of the retrieval algorithm for GOSAT SWIR XCO₂ and XCH₄ an validation using TCCON data

Y. Yoshida', N. Kikuchi', I. Morino', O. Uchino', S. Oshchepko T. Saeki¹, N. Schutgens¹, G. C. Toon², D. Wunch⁴, C. M. Roeh P. O. Wennberg⁴, D. W. T. Griffith⁵, N. M. Deutscher^{5,6}, T. Warn J. Robinson⁷, V. Sherlock⁷, B. Connor⁹, M. Rettinger⁸, R. Susa P. Ahonen¹⁰, P. Heikkinen¹⁰, E. Kyrö¹⁰, and T. Yokota¹

"National Institute for Environmental Studies, 16-2 Onogawa, Taukuba 3 ⁶Atmosphere and Ocean Research Institute, University of Tokyo, 5-1-5 K Kashiwa 277-8568, Japan

Jet Propulsion Laboratory, California Institute for Technology, 4800 Cak Pasadena, CA, 91109-8099, USA

California Institute for Technology Pasadena, CA, 91125-2100, USA Center for Atmospheric Chemistry, University of Wollongong, New South Wales 2522, Australia

Institute of Environmental Physics, University of Bremen, 28334 Breme National Institute of Water and Atmospheric Research, Wellington, New

949

Almos. Chem. Phys. Discuss., 13, 3020-0248, 2013 www.atmos-chem-phys-discuss.heim150300013r doi:10.5194/word-13-3003-2013

Chernistry and Physics © Authorital 2013. CC Attribution 3.0 License

The sha caster, paper school frees Lights Weeka for the Journal Automptions Chartery's and Physics (ACP). Please little to the consecuting feet paper to ACP P security.

AMTD

8 949-988 2013

Improvement of the retrieval algorithm for

GOSAT SWIR XCO. and XCH₄

Validation of XCO₂ derived from SWIR spectra of GOSAT TANSO-FTS with aircraft measurement data

M. Inoue', I. Morino', O. Uchino', Y. Miyamoto', Y. Yoshida', T. Yokota', T. Machida¹, Y. Sawa², H. Matsueda⁵, C. Sweeney⁴, P. P. Tana⁴, A. E. Andrewa⁴, and P.K. Patra

"National Institute for Environmental Studies (NIES), Taukuba, Japan ²Graduate School of Natural Science and Technology, Okayama University, Okayama, Japan ³Meteorological Research Institute (MRI), Tsukuba, Japan

*National Oceanic and Atmospheric Administration (NOAA), Boulder, CO, USA ⁵Research Institute for Global Change, JAMSTEC, Yokohama, Japan

Received: 30 November 2012 - Accepted: 21 January 2013 - Published: 4 February 2013

Correspondence to: M. Inoue (incue makoto@nies.go.jp)

Published by Copernicus Publications on behalf of the European Geosciences Union.

Yoshida et al. (2013) AMTD, 6, 949-988 Inoue et al. (2013) ACPD, 13, 3293-3246

Abrice preiric

ACPD 13.3205-5248.2013 Validation of GOSAT XCO₂ using aircraft measurement M. Incus et al.

Yorkey Inventity Venue

Managers A

SWIR L2 V02.** Algorithm & Validation papers

Greenhouse aase





TANSO-CAI L3 NDVI (V01.00)



Contribution of satellite data to carbon flux





15

Improved regional CO₂ fluxes AAA

Demonstrated the utility of satellite-based concentration data in the estimation of global CO₂ fluxes







Model Simulated global CO_2 concentrations in three dimensions calculated from monthly regional CO_2 flux estimates (GOSAT Level 4A data product) by using an atmospheric tracer transport model.



Daily mean animation of global CO_2 on a 2.5° × 2.5° latitude-longitude grid at an altitude of ~ 800 m (June 2009 – May 2010)

Progress during 2012-2013 (2)



- 2012-2013
 - Estimated Geolocation Data (EGD) of the field of view of the TANSO-FTS has been estimated and provided to the users routinely.

Note on FTS L1B geolocation error

FTS L1B geolocation error and pointing offset angle are evaluated by using FTS FOV monitoring camera (CAM). The correction table is averaged over 2 weeks or stable period.



Progress during 2012-2013 (2)



- 2012-2013
 - Estimated Geolocation Data (EGD) of the field of view of the TANSO-FTS has been estimated and provided to the users routinely.
 - The photon path length probability density function (PPDF) method has progressed.

Geometry of the light scattering problem



S. Oshchepkov & A. Bril (NIES)

A simple illustrative example what is PPDF

In absence of aerosol and clouds PPDF is delta function because only pathlength L exists. Light scattering by aerosol and cloud could both decrease↓ and increase↓ the light path depending on the surface albedo. Both of these effects lead to broadening of the PPDF

We have shown that PPDF under different combinations of aerosol and cloud optical characteristics could be parameterized by four parameters for each atmospheric each layer:









- The PPDF-DOAS (PPDF-D) method has been implemented in the NIES GOSAT DHF system.
 - CAI cloud check → PPDF screening → DOAS retrieval
 → Post-screening (SNR & spectral residual chi-square)
- The retrieved data of XCO₂ will be available soon to the registered researchers as data of research for reference.
- A new approach to retrieve PPDF parameters and gas concentrations named `PPDF-S' has been progressed.







- The PPDF-DOAS (**PPDF-D**) method has been implemented in the NIES GOSAT DHF system.
 - CAI cloud check → PPDF screening → DOAS retrieval
 → Post-screening (SNR & spectral residual chi-square)
- IWGGMS-9 Poster No.3 Andrey Bril, et al. (NIES, Japan)
 Retrievals of atmospheric CO₂, CH₄ and optical path modifications from the GOSAT observations
- A new approach to retrieve PPDF parameters and gas concentrations named `**PPDF-S**' has been progressed.

GOSAT Research Promotion



Research Announcement (RA)

- Research Topics
 - 1) Calibration
 - 2) Data Processing Algorithm
 - 3) Validation
 - 4) Carbon Balance Estimation and Atmospheric Transport Models
 - 5) Data application
- > The 1st GOSAT RA in 2008: 52
- > The 2nd GOSAT RA in 2009: 36
- > The 3rd GOSAT RA in 2010: 18
- > The 4th GOSAT RA in 2012: 5
- > The 5th GOSAT RA in 2013: 5

• <u>Rights of the RA Pls</u>

- Submitting GOSAT observation requests
- Access to the GOSAT standard products with priority
- Access to the GOSAT research products



Japan Aerospace **Exploration Agency** (JAXA)



116 research subjects were selected.

National Institute for Environmental Studies (NIES)



Ministry of the Environment (MOE)

GOSAT Research Promotion



- Research Announcement (RA)
- Research Topics
 - Three Parties have been collecting
 - the research proposals at anytime as
 - 4 the Project progresses.

Atmospheric Transport Models

- 5) Data application
- > The 1st GOSAT RA in 2008: 52
- > The 2nd GOSAT RA in 2009: 36
- > The 3rd GOSAT RA in 2010: 18
- > The 4th GOSAT RA in 2012: 5
- > The 5th GOSAT RA in 2013: 5

• Rights of the RA PIs

- Submitting GOSAT observation requests
- Access to the GOSAT standard products with priority
- Access to the GOSAT research products





Japan Aerospace Exploration Agency (JAXA)



National Institute for Environmental Studies (NIES)



Ministry of the Environment (MOE)

Near Future Plan



- The project will continue the GOSAT RA.
- GOSAT standard data products except for TANSO-FTS SWIR & TIR Level 3 are available to general public via the GOSAT data distribution server GUIG (GOSAT User Interface Gateway): http://data.gosat.nies.go.jp/

- TANSO-FTS SWIR & TIR Level 2 data will be upgraded in versions in a year or so.
- Level 4A (& 4B) CH₄ data products may be available in this fiscal year.







Related presentations @ IWGGMS-9

BUSITION Related presentations on GOSAT @ IWGGMS-9 by researchers and engineers of the GOSAT Project in Japar

- Oral Presentations
 - May 30 (Thu) PM

Sensor Cal. (Level 1)

- Level1 Algorithm for TANSO-FTS on GOSAT: Calibration and Correction of four years data by A. Kuze (JAXA)
- May 31 (Fri) AM

(Level 4) Algorithm & Results

- Inverse modeling of the regional CO₂ fluxes with GOSAT XCO₂ observations by S. Maksyutov (NIES)
 (Level 4) comparison
- Inter-comparison of surface CO₂ fluxes estimated from latest GOSAT XCO₂ products using a single inverse modeling scheme by H. Takagi (NIES)
- GOSAT-2 related Presentations
 - Lessons and Learned from GOSAT towards GOSAT-2 by H. Suto (JAXA) [Oral]
 - Development of the GOSAT-2 FTS Simulator by A. Kamei (NIES) [Poster]



- Poster Presentations
 - May 30 (Thu) AM

(Level 2) SWIR Retrieval

- 2) Extension of the targets for the GOSAT SWIR XCO₂ and XCH₄ retrievals by Y. Yoshida (NIES)
 PPDF-S Retrieval
- 3) Retrievals of atmospheric CO₂, CH₄ and optical path modifications from the GOSAT observations by A. Bril (NIES)
- 4) An Algorithm for Greenhouse Gas Retrievals Using Polarization Information Measured by GOSAT TANSO-FTS by N. Kikuchi (NIES)
 (Level 2) SWIR Algorithm
- 5) Validation of GOSAT SWIR XCO₂ and XCH₄ using TCCON data: Parameter dependency of GOSAT biases and the bias correction by M. Inoue (NIES)
 (Level 2) SWIR Validation
- 9) Impact of aerosols and cirrus clouds on the GOSATobserved CO₂ and CH₄ inferred from ground-based lidar, skyradiometer and FTS data at prioritized observation sites by T. Sakai (MRI)
 (Level 2) SWIR Validation



- Poster Presentations
 - May 30 (Thu) AM
 - 15) Characterization of GOSAT TANSO Level 1 V160.160 TIR spectra by K. Shiomi (JAXA)
 (Level 2) TIR
 - 16) Profiles of CO₂ and CH₄ retrieved from GOSAT/TANSO-FTS thermal infrared spectra using an improved algorithm by N. Saitoh (CEReS/Chiba U.)
 - 21) Impact of high resolution meteorological fields on simulation of high frequency variability of CO₂ concentration using FLEXPART with 1km flux maps by R. Janardanan Achari (NIES)
 - 22) Developing adjoint of the coupled Eulerian-Lagrangian transport model by D. Belikov (NIES)
 (Level 4)
 - 24) Regional CH₄ flux estimates based on GOSAT SWIR L2 and ground-based observations by H-S. Kim (NIES)

(Level 2) TIR Retrieval





- GOSAT TANSO-FTS SWIR Level 2 data products (XCO₂ & XCH₄) have been updated to V02.**. All of the observational data in the past for almost four years have been reprocessed as V02.** data products.
- A new version of TANSO-CAI Level 3 NDVI product has been open to general users.
- GOSAT data products are available via the GOSAT user interface gateway (GUIG): http://data.gosat.nies.go.jp/
- Level 4A & 4B products during June 2012 and May 2010 are also available from the GUIG.







