



NIES GOSAT PROJECT NEWSLETTER

Independent Administrative Institution
National Institute for Environmental Studies (NIES)
A newsletter on the Greenhouse gases Observing SATellite (GOSAT, "IBUKI") project from the NIES GOSAT Project Office.

<http://www.gosat.nies.go.jp/>

NEWS COP19/CMP9 Report

S. Pang, Specialist / T. Matsunaga, Leader
GOSAT-2 Project Team, NIES

UNFCCC COP19/CMP9 started on November 11, 2013 in Warsaw, the capital of Poland. This is the second time for Poland to host this international conference, the first of which was COP14 held in Poznan, the one of the oldest cities of Poland, in December 2008. Warsaw is the largest city in Poland restored up to each crack in a brick after once destroyed in World War II, and named to the UNESCO list of world heritage in 1980 as "Historic Center of Warsaw". It is also the birthplace of Chopin, the poet of the piano, and Madame Curie, the Nobel Prize winner in Physics and Chemistry (Photo #1: Fryderyk Chopin Museum, #2: Maria Skłodowska-Curie Museum). They use public transportation of trains, buses, street cars, etc. very often. We used street cars between the hotel and the venue.



COP17 in 2011 had hammered out Durban Agreement which binds governments to adopt by the end of 2015 a universal legal agreement on climate change (Durban Platform) beyond 2020, the last year of the second commitment period of Kyoto Protocol, and COP19 now achieved results that all Parties are to

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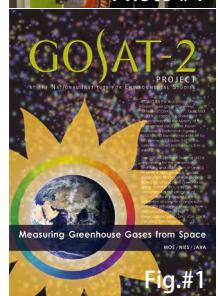
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initiate domestic preparations for their nationally determined contributions and to communicate them well in advance of COP21 in 2015 and also to identify the information to be provided in putting them forward by COP20. For more details, please refer to http://www.mofa.go.jp/policy/page3e_000130.html.

At present there are 195 Parties and COP19/CMP9 saw 10,106 registrations (4,779 government officials, 173 from UN, 151 from specialized agencies, 446 from international organizations, 3,586 from NGO, and 971 from media), 181 side events and 173 booths besides many conferences (Photo #3: The National Stadium, the venue).

NIES displayed at its booth (Photo #4) during the first week (Nov. 11 (Mon) – 16 (Sat)) a scenario to realize Asian low carbon society, climate simulation based on global climate model MIROC5, animated simulation of global CO₂ concentration by GOSAT data, the latest status of GOSAT-2 under development (whose flyer in Fig. #1), global warming research funded by MOE, etc. showing its



wide variety of environmental research and its outcome. As the UN Secretariat advocates "walk the talk" and "lead by example" these years and manages its hosting conferences in that way, we NIES mainly used CDs*1 for handing out pamphlets/flyers to visitors to reduce paper consumption wherever possible. As for GOSAT/GOSAT-2, we presented to the visitors global CO₂/CH₄ column averaged concentration map (L2 product) from June 2009 to April 2013, 64-regional monthly averaged global CO₂ flux map (L4A product), global CO₂ distribution (L4B product) from June 2009 to October 2011, GOSAT-mounted TANSO-CAI images of haze over Singapore and volcano eruption in Iceland, etc. using large screen tablets, posters, banners, pamphlets, and flyers.

Many delegates from the Parties also visited and laid eyes on displayed materials and brought back CDs and other handouts. Those from African countries showed lots of interests on typical 10 actions*2 suggested to realize low carbon society in Asia and also seemed interested in the above mentioned CO₂ concentration animated simulation on African continent.

Dr. Yokota, the GOSAT Project Leader, was interviewed by Peoples Daily and China Radio International. They asked "How is Japan going to contribute to the Conference as an advanced country?" His answer was, "We share all GOSAT outcome among scientists in the world including China to support their researches and I, as a scientist, have made contributions to establish scientific basis for UNFCCC through better observation of greenhouse gases' concentration and flux in the atmosphere. They appreciate our GOSAT project very much because of the amazing increase of the observation points realized by the satellite added to ones by the observation on land/sea, which has greatly alleviated the problems of deficiency and uneven distribution of those points."

During the second week of Nov. 18(Mon) – 22(Fri), after the closure of NIES booth, we had GOSAT-2 banner stand in front of Japan Pavilion and at Japan booth, I (Matsunaga)

distributed GOSAT handouts and presented slides/movies using a compact projector. GOSAT-2 was introduced here at least two times: (1) at Japan's "Proactive Diplomatic Strategy for Countering Global Warming" published on Nov. 15(Fri) referring to GOSAT-2 scheduled launch in FY2017 on the second item of "Application", (2) at a side event on the second week.

During the Conference, there were heated discussions on calculation method of GHG emission amount, reduction target of each country, economic aid on developing countries to preserve the forest, etc. and we heard an episode telling that emerging/developing countries like China, India, Venezuela, etc. indicated dissatisfaction on the term "commitment" used on the Agreement between the Parties and it was adjusted to "contribution" finally.

The registration to COP/CMP is increasing every year and admission limit to the venue is becoming harder, so some measures were taken to ease the situation: sharing electronically on smartphones/Internet such information as documents under negotiation, agenda of conferences, venue guide, etc. including weather forecast, transportation, emergency hospitals, daily conversation in Polish, etc. I (Pang) could watch a live broadcasting on Web back in Japan in the early morning of Nov. 24 (in Poland 5 p.m., Nov. 23), to know how they finally adopted the consensus document working one more day after the schedule. Multinational agreement is really difficult to make on an action program even if they share the awareness on global warming.

Next COP20/CMP10 will be held in Lima, the capital of Peru, in December 2014.



*1 Contents in handout CD can be seen on "3. GOSAT Project" in http://www.nies.go.jp/media_kit/index-e.html.

*2 Please refer to http://2050.nies.go.jp/file/ten_actions_2013.pdf for more details.

NEWS Named and Awarded

Prof. Paul Wennberg (Photo #1), California Institute of Technology and chair of TCCON*1, was cited for his "seminal contributions to our understanding of atmospheric chemistry" by the American Geophysical Union (AGU) as he was named to the 2013 Class of Fellows, an honor bestowed on no more than 0.1% of AGU members in any year.



Photo #1

Also Dr. Tatsuya Yokota (left in Photo #2), NIES GOSAT Project Leader, was awarded Horiuchi Award 2013 by Meteorological Society of Japan for his contribution to the

promotion of GOSAT project. The prize is intended to bestow those who have greatly affected the development and improvement of meteorology or its related technology through their research/study/writing, etc. in the boundary/adjacent/unprecedented field of the science.



Photo #2



*1 Total Carbon Column Observing Network is a network of the ground-based high-resolution FTS observations. Currently, its observations are carried out in about twenty locations worldwide. TCCON's column-averaged abundances of greenhouse gases are used for validating greenhouse gases observation by satellites and other carbon cycle studies.

NEWS**ESA "Living Planet Symposium" Report**

T. Yokota, Leader, GOSAT Project, Center for Global Environmental Research, NIES

 The symposium mentioned above was held on September 9-13, 2013 at Edinburgh International Conference Centre, UK. That is held every 3 years from 2004 hosted by European Space Agency (ESA) to present scientific results and plans on Earth diagnosis and prediction by satellites, focusing around ESA's ENVISAT data including related satellites and future missions. It was the fourth of serial symposia (refer to <http://www.livingplanet2013.org/>).



- Photo #1

Except for Opening (Photo #1) and Closing Plenary Sessions, there were 144 sessions held parallelly in 9 independent rooms, gathering more than 1800 participants. GOSAT has been placed as

one of ESA's third party missions and its data are used by ESA researchers together with data from SCIAMACHY^{*1} and others. They reported on GOSAT, mainly from European universities/ Institutions (University of Leicester, University of Edinburgh, KIT/SRON^{*2}), in sessions such as Greenhouse Gases (1) - (3), Greenhouse Gases (GHG) – ESA Climate Change Initiative (CCI), Data Assimilation, etc., showing outcomes that the retrieval accuracy of CO₂/CH₄ column-averaged concentrations by GOSAT data has been improved and they are useful for estimating flux and monitoring regional specific events. There were also poster sessions besides oral presentations, zoned in an unusual way of broad corporate exhibit area and coffee break corner placed at the center and poster boards aligned around them (Photo #2: grey panels put along yellow back wall are poster boards; at the

center is a model of Envisat (arrowed)).



Photo #2

Also prior to this symposium, Dr. M. Buchwitz of University of Bremen et al. held a press conference at GHG-CCI (<http://www.esa-ghg-cci.org/>) on September 4, 2013, to announce the accomplished CO₂/CH₄ trend observed by SCIAMACHY and GOSAT for more than 10 years (refer to <http://www.esa-ghg-cci.org/?q=node/118>). 

*1 SCanning Imaging Absorption spectroMeter for Atmospheric CHartographY is the sensor mounted on the ESA satellite Envisat, which was in operation from March 2002 to April 2012.

*2 Karlsruhe Institute of Technology/Netherlands Institute for Space Research

NEWS GEO^{*1} Conference / Meeting Report

 I attended International Conference "Towards a Global Carbon Observing System: Progresses and Challenges" (Oct. 1 - 2) and Meeting of the GEO CL-02^{*2} task "Global Carbon Observations and Analysis System" (Oct. 3 - 4) held at World Meteorological Organization, Geneva. There were total 99 attendee including 9 from Japan: Dr. Saigusa from NIES, Dr. Kondo/ Dr. Murayama from National Institute of Advanced Industrial Science and Technology, Dr. Shiomi from JAXA, Dr. Ghosh from National Institute of Polar Research, Associate Professor Imasu of the University of Tokyo (Oct. 3 - 4 only), Mr. Ochiai/Ms. Mano of GEO Secretariat, and myself.

In the first half of the Conference they presented the latest outcomes in observation and modelling of carbon cycle and GHGs on various levels from study to policy, targeting at elements'

extraction required for global carbon cycle observation system design and proposal creation for policy makers to be distributed at Earth Observation Summit, January 2014. The presentation consisted of 6 sessions (1: Tropical C-budget and hotspots, 2: In situ observations, 3: Observations from space, 4: Global methane cycle, 5: Model data fusion at global and regional scale, 6: Carbon and policy), 37 oral presentations including a keynote speech, and 42 posters.

I presented "GOSAT and GOSAT-2: Achievements and Future Plan" in session #3 and Dr. Shiomi made a poster presentation titled "GOSAT-2 Mission Requirements and Concepts". Dr. D. Crisp, Dr. M. Buchwitz, and Dr. D. Jacob also made presentations on GHGs observation from space.

In the latter half of the Meeting they reported outcomes by existing/new

T. Matsunaga, Leader
GOSAT-2 Project Team, NIES

activities related to GEO task CL-02 and discussed how to enhance linkage between members and create the proposal mentioned above. The first day had 14 reports including those from Japan: GOSAT status by Dr. Shiomi, CO₂ flux estimates in Kanto area with top-down method by Associate Professor Imasu, and activity reports by Dr. Saigusa/ Dr. Kondo/ Dr. Murayama. The second day had heated discussions on cooperation on CL-02 and the contents of the proposal.

It was really a meaningful opportunity for us to be able to overview the latest status of carbon cycle observation and modelling, and exchange opinions on and discuss the future development. 

*1 "GEO" stands for "Group on Earth Observations."

*2 This means #2 task on CLimate, whose theme is "Global Carbon Cycle Observation and Analysis."

GOSAT PEOPLE

Observing Clouds, Diagnosing Environment

Prof. T. Y. Nakajima, School of Information Science/Research and Information Center (TRIC), Tokai University



Clouds always in my sight

I am in a habit of looking into the far distance since my boyhood. On a train or in a car, my eyes always go directly to the farthest and broadest sky or horizon. Born and bred in a city, rows of houses went on and on around me, so I loved to watch the endmost edge of the landscape catching clouds whenever we were out to the suburbs. This habit since my infancy seems to connect to my study, cloud science and cloud observation.

***IBUKI* and clouds**

I am now observing clouds using GOSAT (*IBUKI*), the joint mission of MOE, NIES, and JAXA. *IBUKI*'s main sensor is a Fourier Transform Spectrometer (TANSO-FTS), accompanied by a Cloud and Aerosol



Imager (TANSO-CAI) to support data processing of TANSO-FTS. The image data from CAI are used to identify the existence of clouds and aerosols within the FTS's field-of-view and to retrieve their optical properties^{*1}.

Instead of human eyes, clouds and aerosols are observed by an unusually sensitive mechanical eye which has the spatial resolution of 500m from 666km above the ground, which is equivalent to find a 1.5m high tree standing 2km away. The mechanical eye, however, has a weak point: it cannot make a synthetic judgment which is easy for human eyes, to judge with a high degree of accuracy what object is in their field of view integrating every situation. The eye catches the object's characteristics by utilizing the light with several wavelengths. I have been trying to find what feature amounts imply the existence of clouds.

This is considerably a difficult work. Viewed from space, which is much different seen from the ground, there are many other bright areas than clouds: snow-covered ground which has the same brightness as clouds, deserts which looks fairly bright as it is, and sunlight reflection on the sea which appears bright almost clouds. These all can lead to misjudgment of cloud existence. It is actually difficult, though seemingly simple, to identify clouds from CAI images. CAI has only 4 bands from ultraviolet to near-infrared. We need to judge clouds using this limited information compared to up-to-date imaging sensors with 20 - 35 bands.

Happy study days with the younger generation

The algorithm to identify clouds from satellite data was developed with my colleagues and graduate students around 2008. Dr. H. Ishida, who is a specialist on atmospheric radiative transfer and an Assistant Prof. of Yamaguchi Univ. now, did a great job in my lab at that time. He took notice on the slight difference of radiative properties between cloud and ground surface and

applied it to develop an effective method to detect clouds. He also introduced the idea of "neutral cloud identification" then, which made the algorithm bias-free from both cloud and clear sky by considering tendencies of sensors' bands whether they are likely to overlook clouds or misjudge clear sky to be cloudy. The algorithm named CLAUDIA^{*2} has the advantage of applicability to many imaging sensors beyond CAI of *IBUKI* because of its most simple design structure.

***IBUKI*, the versatile player**

Now it is time for us to have a clear vision of the global environment to hand over to the next generation and to take any action if required. Observation comes first to have a correct vision. Japan's GOSAT (*IBUKI*) with a leading-edge FTS is a satellite to be boasted to the world. First, it has accommodated the global observation of GHG concentration distribution to identify anthropogenic effect in carbon cycle. Second, it also has shown how it is versatile with its CAI in recognizing various events such as volcanic eruptions and atmospheric pollutions which greatly affect civil life. For example, the CAI's high resolution and performance, which can distinguish plume from clouds clearly, attracted the world's attention during volcanic eruptions^{*3} in Iceland occurred in April 2010 and May 2011. These roles of *IBUKI* are taken over by its successor (GOSAT-2).

Caring trees to raise forests

You may think the global observation from space is not directly related to your daily civil life, but it is. Apart from *IBUKI* a bit, let me tell you about the study in power and energy fields where I lately involved and the observation has a great role. There will come an age of energy mix to use renewable ones like solar and wind, and actually their plants are increasing at a frightening pace as you know. This indispensable power's supply and demand need to be always balanced not only in total, but in temporal scale from a second to a week, and also in various spatial scale from city/town/village to country/region, and solar and wind, the most available ones now, depend greatly on the weather, which proves the importance of geoscience and observation from space. The new energy management system to be established from now must also be stable and sustainable against environmental changes, which requires a long-term consideration to climate change. CLAUDIA, developed during the CAI studies, can help identify clouds from space and the FTS measures GHGs with high precision to support global warming study. Thus the presence of satellites like *IBUKI* and its successor will become greater and greater. I mainly observe ever-changing clouds, however, my eyes go far into the future globe in terms of centuries. So I feel like a man of silviculture these days who closely takes care of each tree in front of me, hoping for the advent of a good forest in several generations.



*1 CAI can specify the aerosol optical thickness, etc. with which you can estimate the influence of aerosol on the observed FTS spectra.

*2 Cloud and Aerosol Unbiased Decision Intellectual Algorithm.

*3 The large-scale eruption of Icelandic volcano in April, 2010 caused a

INTERVIEW

A Series: *IBUKI*'s PI Interview

No.11 Karlsruhe Institute of Technology

Dr.

André Butz

Dr. André Butz visited Japan last May to attend the 5th GOSAT RA PI Meeting and IWGGMS-9. This interview was held at the opportunity in Yokohama and the one got last following #28 (Dr. Camy-Peyret) and #29 (Prof. Notholt) interviews.

He is at the young age of early 30s with a voice clear and rich in overtones (this was really helpful in transcribing the recorded interview), stating difficulties and challenges, the importance of balance between theory and model, and social significance of observation from space.

(Interviewers: T. Yokota and Y. Yoshida, NIES GOSAT Project)



○○○ **NIES** (hereafter **N**) Thank you for coming here. At first I'd like to ask you where you were born and your student time and which field have you learned, and why did you select your institute and your job.

Dr. Butz (hereafter **B**) I was born in Germany, in the northern part of Bavaria. After school, I started studying physics at Würzburg University in Germany. Then I moved to the US where I did my Master's degree in atomic physics at the State University of New York at Stony Brook. My master project investigated the quantum-mechanical Stark effect^{*1} in a beam of hydrogen atoms that were subject to external electric fields. When changing the direction and strength of the electric fields, we could observe sudden or adiabatic population transfer in the Stark states depending on the rate of field change we applied. Interestingly, we could predict this behavior by a quantized version of classical mechanics. After one year at Stony Brook, I went back to Europe where I started my Ph.D. with Prof. Klaus Pfeilsticker from Heidelberg, and Prof. Claude Camy-Peyret^{*2} from Paris. My Ph.D. focused on solar occultation^{*3} measurements from a balloon that went up into the stratosphere. I had

the chance to work with the UV/visible spectrometers of the Heidelberg group and Prof. Claude Camy-Peyret's infrared Fourier Transform Spectrometer (FTS). At the time, I participated in several ballooning campaigns for example in the Arctic and in tropical Brazil. The goal was to learn more about stratospheric photochemistry and how much of ozone destroying halogens are transported up there. The campaigns at Brazil were particularly interesting since the tropical tropopause is the region which all the molecules have to go through to get into the stratosphere. Of course, Brazil is an interesting place to visit anyway. In 2006, I got my Ph.D. as a bi-national degree from the universities at Heidelberg and Paris. Afterwards, I joined the Netherlands Institute for Space Research – SRON to work on satellite remote sensing. This was the time when I started working on radiative transfer and greenhouse gases.

N: So you were a member of Prof. Ilse Aben's group?

B: Yes, exactly. Her group started developing the RemoTeC algorithm which is also the backbone of my current work - now, that I am back to Germany, at the Karlsruhe Institute

of Technology. I got funding from the German government to set up a small research group. In Germany, we call this a "young investigator group". As you know, we continue working on greenhouse gas retrievals from GOSAT, but we also work on inverse modeling and on developing ground-based instrument. Next year, we hope to conduct a measurement campaign with a newly developed ground-based spectrometer.

N: What is the purpose RemoTeC has been developed for?

B: The primary purpose was to develop a retrieval method that can achieve the accuracy that is required for making remote sensing of greenhouse gas concentrations a useful tool. In the end, we want to gain insight into the carbon cycle processes.

N: Greenhouse gases --- not specific sensors or satellites?

B: Well, when developing RemoTeC, we had in mind that GOSAT and OCO^{*4} satellites would be the first satellites the algorithm could be applied to. But, we tried to keep RemoTeC as flexible as possible such that it would be easy to adapt the code to other satellites. In

*1 The shifting and splitting of spectral lines of atoms and molecules due to presence of an external electric field.

*2 Please refer to "*IBUKI*'s PI Interview" in GOSAT Newsletter #28 (<http://www.gosat.nies.go.jp/eng/newsletter/newsletter28e.pdf#page=6>).

*3 Solar occultation technique is to observe sunlight directly that

comes through the atmosphere each time a satellite makes an orbit. On the other hand, *IBUKI* employs a nadir-looking method, which observes sunlight reflected on the ground or the direct light coming from the Earth by pointing downward on the ground. Please refer to: <http://www.gosat.nies.go.jp/eng/newsletter/newsletter15e.pdf#page=7>.

the beginning we did some test with SCIAMACHY^{*5} data, but we quickly moved to OCO and GOSAT, in particular since there were already several algorithms available for SCIAMACHY.

N: What about the future CarbonSat^{*6} or other missions?

B: Of course, we would be happy to run RemoTeC on GOSAT-2^{*7}, OCO-2, or CarbonSat observations. RemoTeC – or a variant of RemoTeC – will probably become the processor for methane retrievals from the European Sentinel-5 Precursor^{*8} mission to be launched in about 2 years.

N: Have you been at SRON at the same time as Dr. Christian Frankenberg^{*9}?

B: I worked at SRON from 2007 to 2011 and, indeed, had several years overlap with Christian. Christian essentially focused on the proxy method^{*10} for methane and water isotopologues, and I developed the full-physics^{*11} method RemoTeC. We were interacting a lot. So, quite some pieces of code in RemoTeC probably originate in some way or the other from work that Christian had done for SCIAMACHY. We were also collaborating on the water and methane spectroscopy in the 1.65 μm band. If I remember correctly, we used a precursor of the current RemoTeC algorithm to run retrievals from ground-based FTS spectra to test the spectroscopic updates Christian needed for SCIAMACHY.

N: You explained, that Dr. Otto Hasekamp and you were jointly developing RemoTeC. How did you share the work?

B: When I was at SRON, Otto was my supervisor. He was largely responsible for developing the radiative transfer

code that is now the heart of RemoTeC. My job was to set up the interface to the radiative transfer module, to take care of the logistics and all the details that are required to make an algorithm work for real measurements. Running simulations and validating the code with TCCON spectra was also a large part of my work. For example, we developed a kind of orbit simulator which we can now apply to future missions such as the Sentinel-5 or its precursor.

N: Now you are also a member of the ACOS^{*12} team.

B: Actually, I am not a member of the ACOS team. But I am a member of the OCO-2 science team. The reason why I'm interested in satellite remote sensing of greenhouse gases is that, first of all, it is a very challenging subject. In order to achieve the required accuracy, the retrieval methods must be very sophisticated and take into account physical processes that typically are neglected for other applications. For example, simultaneously retrieving aerosols and greenhouse gas concentrations needs state-of-the-art input from the radiative transfer, spectroscopy, and the trace gas retrieval communities. The other very interesting aspect of our work is of course the chance to learn more about climate change. In that sense, pushing the accuracy of our carbon dioxide and methane measurements could in the end lead to a better understanding of the climate system and how to deal best with climate change.

N: Are you mainly interested in the species carbon dioxide and methane?

B: Currently, these are my main interests. But during my Ph.D. I mostly worked on short-lived substances such

as ozone and halogen oxides. I would also be interested in remote sensing of aerosol and cloud properties.

N: Do you have any plan to apply your retrieval also to the thermal infrared or other spectral regions?

B: So far, we focus on the SWIR. But, we have plans to combine SWIR and TIR radiances to gain vertical profile information. This would help the source/sink inversion a lot. Combining the SWIR and TIR requires quite some algorithm development on our side. Therefore, it will take a while until we can claim a success. There are also some ideas around for new satellite missions covering both, the SWIR and the TIR. So, it would be great to show with GOSAT that the idea works.

N: Especially for methane profile information?

B: Yes, methane would be the first target since it appears an easier target than carbon dioxide. Carbon dioxide is often used for temperature retrieval in the TIR. If we want to retrieve its concentration, we would first need to come up with an alternative for the temperature retrieval.

N: What do you think about the present status of the GOSAT project?

B: I think, it is an excellent project. The satellite is operational and delivers high-quality data for more than 4 years, which is a great achievement by itself. The GOSAT team has a very open attitude which makes international collaboration possible. I think, this is really key to the great success of GOSAT so far. Personally, I like interacting with the level 1 and level 2^{*14} teams. It is always interesting to learn about some instrument detail that makes the performance of our algorithm better

*4 Orbiting Carbon Observatory (OCO) is one of the missions of Earth System Science Pathfinder Project in NASA, USA, a satellite dedicated to studying atmospheric CO₂. The launch of OCO-1 unfortunately failed in February, 2009, however, its successor OCO-2 has been developed by NASA and is waiting for the launch scheduled in July, 2014.

*5 SCanning Imaging Absorption spectroMeter for Atmospheric CHartographY is the sensor mounted on the ESA satellite Envisat, which was in operation from March 2002 to April 2012.

*6 Carbon Monitoring Satellite is planned and led mainly by Bremen University in the ESA's Earth exploration project, targeting at global observation of CO₂ and CH₄ concentrations, to be launched in 2018.

*7 Greenhouse gases Observing SATellite-2 is the successor to the GOSAT and scheduled for launch in early 2018.

*8 Sentinel-5 Precursor is a satellite specialized in atmospheric observation to be launched in 2015 as part of ESA's Sentinel project, which is aiming at multisatellite observation of land, ocean, and atmosphere.

*9 Please refer to "IBUKI's PI Interview" in GOSAT Newsletter #4 (<http://www.gosat.nies.go.jp/eng/newsletter/newsletter04e.pdf#page=3>).

*10 Please see "AHA! OF THE MONTH" on next page.

*11 Please see "AHA! OF THE MONTH" on next page.

*12 Atmospheric CO₂ Observations from Space team is a group organized around OCO (Orbiting Carbon Observatory) science team involving researchers of JPL^{*13}, Caltech, and Colorado State University.

*13 Jet Propulsion Laboratory is a federally funded research and development center and operated by Caltech for NASA.

or worse. Our algorithm development benefits a lot from the discussion with the level 1 team. On the other, I think that also the level 1 developments benefit from sensitivity studies we do on the level 2 side.

N: What is it that made you move from pure physics into the field of greenhouse gas measurements?

B: Satellite remote sensing of greenhouse gases is an interesting physics problem. Radiative transfer theory and spectroscopic theory are actually quite on the theoretical side of physics problems. But then, it is not only about theory. Rather, we develop physical models that actually fit real-world measurements. And, our results even have some societal impact. I like working on problems where one can choose to focus more on the theoretical or the experimental aspects.

N: What is the expectation and recommendation to the future GOSAT or GOSAT-2 projects?

B: Well, for GOSAT, I would hope that the mission and our collaboration with the GOSAT team will continue for a long time. It would be really great to

extend the carbon dioxide and methane records from GOSAT into the future to have considerable overlap with OCO-2 and the Sentinel-5 precursor. Seeing the success of GOSAT, I would think that GOSAT-2 should try to preserve the key qualities and to improve on some deficient aspects. GOSAT's key quality is that it is a Fourier Transform Spectrometer with wide spectral coverage and good spectral resolution. Simultaneously covering the shortwave and the thermal infrared is for example quite a unique feature. It would be great if GOSAT-2 covers the carbon monoxide band at 2.3 μm . Carbon monoxide could be a tracer of certain source processes. If the calibration and performance of the

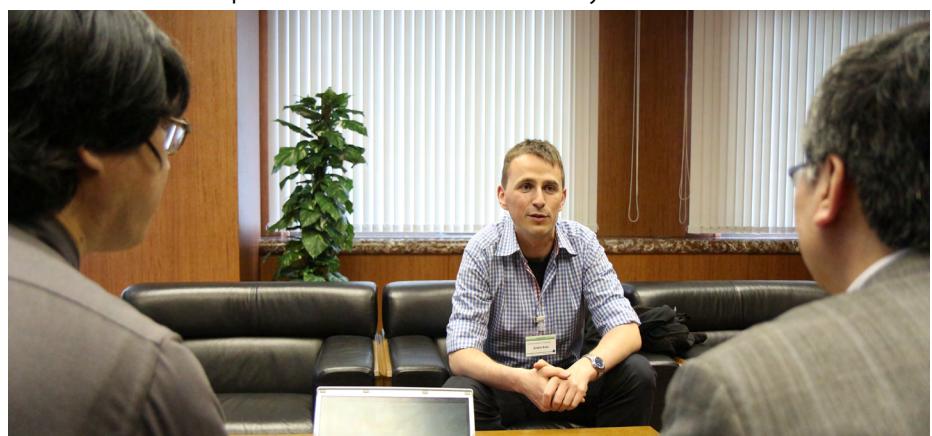
instrument is sufficiently good, GOSAT-2 could then exploit vertical profiling capabilities for carbon dioxide and methane and source correlation with carbon monoxide.

N: Thank you for your time. Do you often visit Japan?

B: Well, quite often recently. It's my 4th time. The 1st time was when the IWGGMS and the RA PI meeting^{*15} were held at Kyoto. Since then, I have been to Tokyo and Yokohama. I like the people and the country and I always enjoy coming here.

N: Thank you for coming.

B: Thank you.



*14 Level 1 is radiance spectral data obtained from observed interferogram data, and level 2 is column abundance data retrieved from radiance spectral data. For more detail, please refer to:
http://www.gosat.nies.go.jp/eng/GOSAT_pamphlet_en.pdf#page=7.

*15 Please refer to "IWGGMS-6 Report" and "The 2nd GOSAT RA PI Meeting Report" in GOSAT Newsletter #2 (<http://www.gosat.nies.go.jp/eng/newsletter/newsletter02e.pdf#page=3>).

SMALL AHA! OF THE MONTH

Proxy Method and Full-Physics Method

Yukio Yoshida, Senior Researcher, Satellite Remote Sensing Research Section, CGER, NIES

The greatest uncertainty in retrieving GHGs from satellite SWIR observation is the modification of optical path length (hereafter the Modification) scattered by clouds/aerosols (hereafter C/A). For example, the length is shortened when the scattered sunlight reaches the satellite before arriving on the ground, or lengthened when scattered repeatedly by the ground and C/A. The degree of the Modification depends not only on the altitude/type/amount of C/A but also ground albedo and wavelength of the observed light. It's difficult to evaluate and eliminate the Modification effect properly.

The Modification's dependence on wavelength is not so great to change itself within narrow wavelength range: it remains almost the same. Proxy method applies this fact to eliminate the Modification's effect using another gas (proxy) as "evaluator". However, it is required: (1) absorption band of both the target and proxy gases to be within a narrow

wavelength range, (2) independent proxy gas's concentration data (e.g., model calculation data) to be ready as the Modification evaluation index. The method enables us to correct almost all the Modification effect, including a margin of error in the index concentration data, on the other hand, attributable to the model, etc.

Full-Physics method handles explicitly detailed information of C/A type/amount, its altitude distribution, etc. "Full-Physics" is named because the method calculates scattering properties and spectra affected by the Modification based on physical quantities which describe C/A, and use the calculation results in analysis. However there is wide variety of C/A, which requires quite a lot of parameters to describe the whole exactly to make some assumptions and simplifications inevitable in analysis, triggering error causes caused by the deviations from truth.

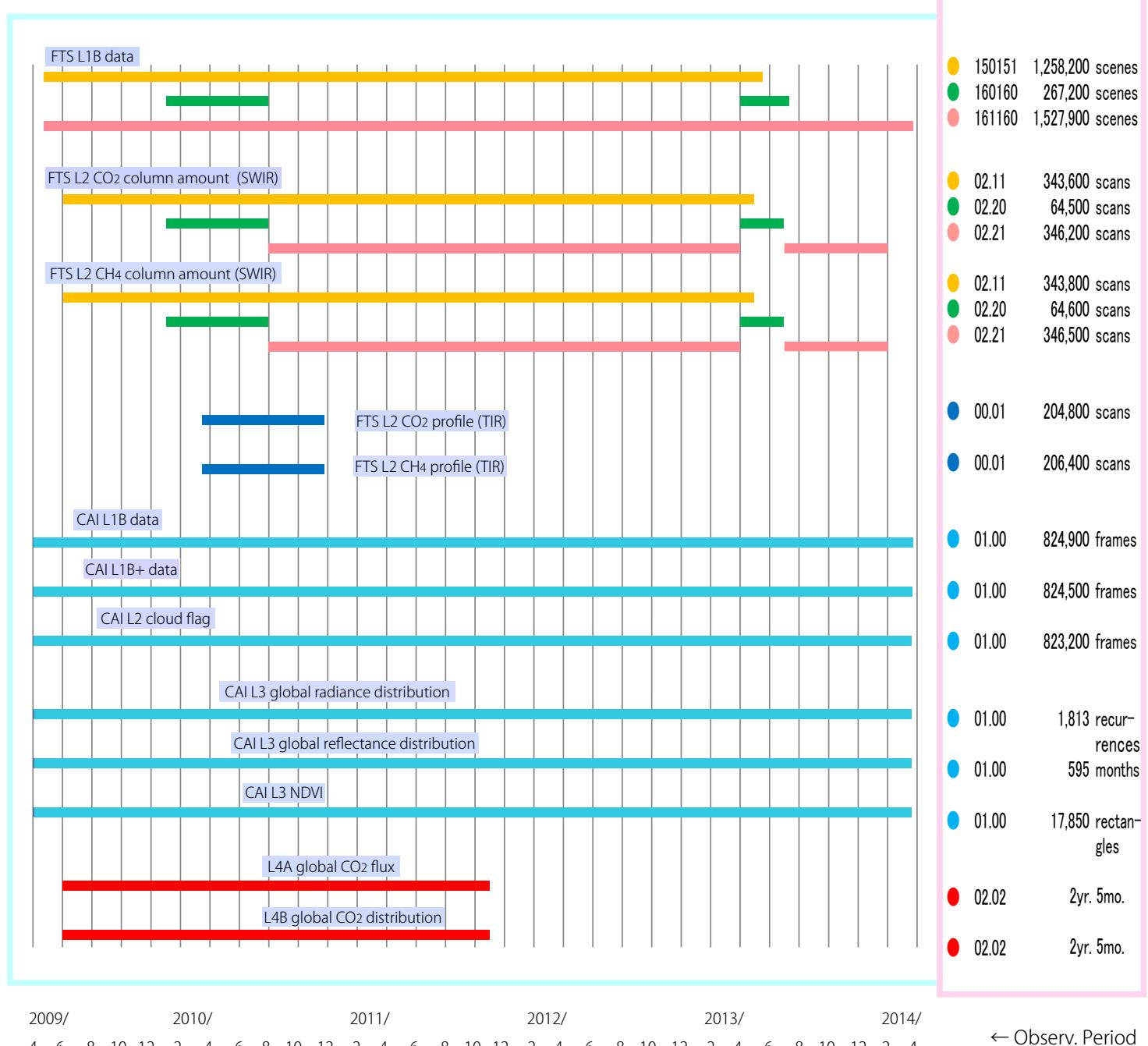
DATA PRODUCTS UPDATE

Data Processing Status Update from GOSAT Project Office

Fumie Kawazoe, Specialist, NIES GOSAT Project Office

Observation Period and Versions of Publicly Released Data

As of March 24, 2014



⌚⌚⌚ The chart above is as of March 24, 2014. The latest processed and released on are: FTS L1B in updated V161.160; CAI L1B/L1B+/L2 cloud flag/L3 global radiance and reflectance distribution, and NDVI in V01.00. FTS L2 CO₂/CH₄ column amount (SWIR) in V02.20 and V02.01 were released on September 26, 2013, at present for the period from January 2010 to January, 2014. Also L4A global CO₂ flux and L4B global CO₂ distribution were released in updated V02.02. For details of change, please refer to "Important Notes at Releasing" in "ATBD, Product Format Descriptions, Product Description, Results of

Validation" in GUIG.

Provision of FTS SWIR L3 (V01.XX) generated from old L2 product (V01.XX) was stopped. Its new version V02.XX FTS SWIR L3 is now under preparation, however, you can preview V02.11 global column averaged distribution in GUIG gallery.

Please see new additions on the gallery from GUIG top, "Monthly Global Map of the H₂O column-averaged volume mixing ratios", "The Images of the Earth captured by IBUKI", and "Global NDVI Map".

The number of registered users is 1649 as of March 24, 2014. 🍏🍏🍏

PUBLISHED PAPERS

- Field of Research:** carbon balance estimation, atmospheric transport models
Name of Journal: Atmospheric Chemistry and Physics
(Volume 13, pages 8695–8717, 2013)
- Title:** Global CO₂ fluxes estimated from GOSAT retrievals of total column CO₂
Authors: S. Basu, S. Guerlet, A. Butz, S. Houweling, O. Hasekamp, I. Aben, P. Krummel, P. Steele, R. Langenfelds, M. Torn, S. Biraud, B. Stephens, A. Andrews, D. Worthy
- Field of Research:** algorithm, validation
Name of Journal: Scientific Online Letters on the Atmosphere
(Volume 9, pages 143-147, 2013)
- Title:** Atmospheric Temperature and Water Vapor Retrievals from GOSAT Thermal Infrared Spectra and Initial Validation with Coincident Radiosonde Measurements
Authors: H. Ohyama, S. Kawakami, K. Shiomi, I. Morino, O. Uchino
- Field of Research:** atmospheric transport models
Name of Journal: Journal of Geophysical Research
(Volume 118, pages 10140–10154, 2013)
- Title:** Background error covariance estimation for atmospheric CO₂ data assimilation
Authors: A. Chatterjee, R. J. Engelen, S. R. Kawa, C. Sweeney, A. M. Michalak
- Field of Research:** carbon balance estimation, atmospheric transport models
Name of Journal: Atmospheric Chemistry and Physics
(Volume 13, pages 9351–9373, 2013)
- Title:** Regional CO₂ flux estimates for 2009–2010 based on GOSAT and ground-based CO₂ observations
Authors: S. Maksyutov, H. Takagi, V. K. Valsala, M. Saito, T. Oda, T. Saeki, D. A. Belikov, R. Saito, A. Ito, Y. Yoshida, I. Morino, O. Uchino, R. J. Andres, T. Yokota
- Field of Research:** data application
Name of Journal: Geophysical Research Letters
(Volume 40, pages 4971–4976, 2013)
- Title:** Toward anthropogenic combustion emission constraints from space-based analysis of urban CO₂/CO sensitivity
Authors: S. J. Silva, A. F. Arellano, H. M. Worden
- Field of Research:** data application
Name of Journal: Atmospheric Chemistry and Physics
(Volume 13, pages 9447–9459, 2013)
- Title:** The covariation of Northern Hemisphere summertime CO₂ with surface temperature in boreal regions
Authors: D. Wunch, P. O. Wennberg, J. Messerschmidt, N. C. Parazoo, G. C. Toon, N. M. Deutscher, G. Keppel-Aleks, C. M. Roehl, J. T. Randerson, T. Warneke, J. Notholt
- Field of Research:** calibration, algorithm
Name of Journal: Atmospheric Measurement Techniques
(Volume 6, pages 2509–2520, 2013)
- Title:** Using ocean-glint scattered sunlight as a diagnostic tool for satellite remote sensing of greenhouse gases
Authors: A. Butz, S. Guerlet, O. P. Hasekamp, A. Kuze, H. Suto
- Field of Research:** validation
Name of Journal: Atmospheric Chemistry and Physics
(Volume 13, pages 9771-9788, 2013)
- Title:** Validation of XCO₂ derived from SWIR spectra of GOSAT TANSO-FTS with aircraft measurement data
Authors: M. Inoue, I. Morino, O. Uchino, Y. Miyamoto, Y. Yoshida, T. Yokota, T. Machida, Y. Sawa, H. Matsueda, C. Sweeney, P. P. Tans, A. E. Andrews, S. C. Biraud, T. Tanaka, S. Kawakami, P. K. Patra
- Field of Research:** algorithm
Name of Journal: Atmospheric Measurement Techniques
(Volume 6, pages 2851–2864, 2013)
- Title:** Semi-autonomous sounding selection for OCO-2
Authors: L. Mandrake, C. Frankenberg, C. W. O'Dell, G. Osterman, P. Wennberg, D. Wunch
- Field of Research:** calibration
Name of Journal: IEEE Transactions on Geoscience and Remote Sensing
(Volume 51, pages 5199–5209, 2013)
- Title:** Testing the Polarization Model for TANSO-FTS on GOSAT Against Clear-Sky Observations of Sun Glint Over the Ocean
Authors: D. M. O'Brien, I. Polonsky, C. O'Dell, A. Kuze, N. Kikuchi, Y. Yoshida, V. Natraj
- Field of Research:** algorithm
Name of Journal: Journal of Geophysical Research
(Volume 118, pages 13520–13531, 2013)
- Title:** New approaches to removing cloud shadows and evaluating the 380nm surface reflectance for improved aerosol optical thickness retrievals from the GOSAT/TANSO-Cloud and Aerosol Imager
Authors: S. Fukuda, T. Nakajima, H. Takenaka, A. Higurashi, N. Kikuchi, T. Y. Nakajima, H. Ishida
- Field of Research:** calibration
Name of Journal: IEEE Transactions on Geoscience and Remote Sensing
(Volume 52, pages 89–105, 2014)
- Title:** TIR Spectral Radiance Calibration of the GOSAT Satellite Borne TANSO-FTS With the Aircraft-Based S-HIS and the Ground-Based S-AERI at the Railroad Valley Desert Playa
Authors: F. Kataoka, R. O. Knuteson, A. Kuze, H. Suto, K. Shiomi, M. Harada, E. M. Garms, J. A. Roman, D. C. Tobin, J. K. Taylor, H. E. Revercomb, N. Sekio, R. Higuchi, Y. Mitomi
- Field of Research:** carbon balance estimation, atmospheric transport models
Name of Journal: Atmospheric Chemistry and Physics
(Volume 14, pages 577–592, 2014)
- Title:** On the consistency between global and regional methane emissions inferred from SCIAMACHY, TANSO-FTS, IASI and surface measurements
Authors: C. Cressot, F. Chevallier, P. Bousquet, C. Crevoisier, E. J. Dlugokencky, A. Fortems-Cheiney, C. Frankenberg, R. Parker, I. Pison, R. A. Scheepmaker, S. A. Montzka, P. B. Krummel, L. P. Steele, R. L. Langenfelds
- Field of Research:** carbon balance estimation, atmospheric transport models
Name of Journal: Geophysical Research Letters
(Volume 41, pages 1065–1070, 2014)
- Title:** Toward robust and consistent regional CO₂ flux estimates from in situ and spaceborne measurements of atmospheric CO₂
Authors: F. Chevallier, P. I. Palmer, L. Feng, H. Boesch, C. W. O'Dell, P. Bousquet

(continued to next page)

Field of Research: calibration

Name of Journal: IEEE Transactions on Geoscience and Remote Sensing
(Volume 52, pages 3991–4004, 2014)

Title: Long-Term Vicarious Calibration of GOSAT Short-Wave Sensors: Techniques for Error Reduction and New Estimates of Radiometric Degradation Factors

Authors: A. Kuze, T. E. Taylor, F. Kataoka, C. J. Bruegge, D. Crisp, M. Harada, M. Helmlinger, M. Inoue, S. Kawakami, N. Kikuchi, Y. Mitomi, J. Murooka, M. Naitoh, D. M. O'Brien, C. W. O'Dell, H. Ohyama, H. Pollock, F. M. Schwandner, K. Shiomi, H. Suto, T. Takeda, T. Tanaka, T. Urabe, T. Yokota, Y. Yoshida

NEWS GOSAT Mission Operation Extended after Nominal Lifetime

T. Yokota, Leader, GOSAT Project, Center for Global Environmental Research, NIES

○○○ The Greenhouse Gases Observing Satellite (GOSAT) *IBUKI*, launched on January 23, 2009, has completed its 5 years' nominal operation as planned. For 3 months after launch, it was in initial operation for functional checkout of each part of the satellite and test of sensors, and in the meantime the first light data were acquired by TANSO-FTS (the Thermal And Near-infrared Sensor for carbon Observation – the Fourier Transform Spectrometer) and TANSO-CAI (the Cloud and Aerosol Imager) on February 7, 2009*¹. After initial calibration and validation, nominal operation started on September, 2009 , and observation data have been acquired almost continuously since June, 2009.

The three parties, JAXA, NIES, and MOE held a meeting to review the nominal operation results of GOSAT at Tsukuba Space Center, JAXA on February 14, 2014, where reported were statuses of the satellite and sensors' functions during the nominal operation, data processing and provision, release of scientific outcomes using GOSAT data, and achievement of

success criteria defined by the Space Development Committee at the initial stage of GOSAT project.

The outcomes during the nominal operation were also reported by the three parties at the 14th Space Development and Utilization Working Group in MEXT on February 24, 2014.

Now *IBUKI* is in extended mission stage after nominal operation and is expected to remain operable long as far as power generation capacity and the amount of fuel left for attitude control are concerned, as no particular trouble has been found with the satellite itself and sensors until now. Without any big change in JAXA's ground system for tracking/controlling the satellite and data reception/processing and NIES' higher level data processing/provision, *IBUKI*'s data products will continue to be processed (/reprocessed as needed) and provided as ever as funding permits.



*1 http://www.jaxa.jp/press/2009/02/20090209_ibuki_e.html

ANNOUNCEMENT

GOSAT Newsletter to Be Closed

○○○ As described above, GOSAT has accomplished its 5 years' nominal operation. At this opportunity, we public relations team reviewed our past activities and found it necessary to reorganize them for more people to recognize GOSAT's mission, its products, and outcomes of researches all over the world.

"GOSAT Newsletter" is to be closed with this issue #30 and we are going to move on to information provision via WEB as

needed, various events, etc., enhancing pamphlets and leaflets at the same time. Please have continued interest on GOSAT project.

Our dear scientists, thank you for your professional writings and proof readings; our dear readers, thank you for your continued support on GOSAT Newsletter.

(S. Aikawa)

