NIES GOSAT PROJECT NEWSLETTER

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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/

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Greetings from Chief Scientist of GOSAT Science Team

by Gen Inoue, Professor, Research Institute for Humanity and Nature
Chief Scientist, GOSAT Science Team

"IBUKI" is promoted by a cooperative partnership among Ministry of the Environment, Japan Aerospace Exploration Agency, and National Institute for Environmental Studies. GOSAT Science Team is a group of scientists who gives scientific advice to them. The central figure of GOSAT Science Team is Chief Scientist Dr. Gen Inoue.

"IBUKI" was successfully launched last year, and since then, it has been working normally although there are minor troubles. Various functional tests and data acquisition have been carried out, and the quality of the obtained spectra exceeds the expected level. We can say that hardware of "IBUKI" was successful. The carbon dioxide concentrations calculated from spectral data are consistent with current knowledge as a whole when there is no cloud or small amount of aerosol within the field of view of the instrument. It should be emphasized that "IBUKI" is obtaining data over the regions where there were no ground or other measurements before. So, I would like to conclude that "IBUKI project is basically successful".

However, this only means the very basic part of the whole objective of "IBUKI" has been achieved, and we need to make more efforts before IBUKI's eventual goal; "Understanding of the global carbon dioxide and methane cycles."

Large efforts must be paid to retrieve the correct concentrations even in the presence of some, not much, amount of interferences such as cirrus cloud and aerosol. This is because the views without any interferences are quite seldom. It will be achieved using all the spectral bands as has been planned at the beginning.

Especially, it is important to be able to retrieve the concentrations over large forests even in the presence of scattered tiny clouds because such clouds often develop due to active evapotranspiration there. The luck of the observation in large forest area, such as tropical forests in South America, Africa or South-east Asia, and boreal forests in Siberia or North America is serious. The filling of the spatial observation gaps will contribute significantly to the science of global carbon dioxide and methane budgets. Very important achievements on sources and sinks, and atmospheric transport will be expected if the quality of concentration data from "IBUKI" is high.

In the future, I think it will become more important to investigate the emissions of carbon dioxide and methane not only in global scale but also in regional scale. If we can utilize "IBUKI" data more to the studies of emission inventories in the regions where statistical data are not well managed, or accidental emissions such as forest fires and leakages of natural gases, IBUKI will gain more reputation. China, India and some countries in South-East Asia and Eastern Europe already show interests in using "IBUKI"'s data for these purposes. It also provides critical information to decide the functions "IBUKI"'s follow-on missions should have.

GOSAT NEWS

The Airborne Observation for the GOSAT Data Product Validation

Tsukuba city seen from the aircraft during the airborne observation. Photo : Tomoaki Tanaka.

—Yuki Tanaka Specialist, Office for the Global Environmental Database, Center for Global Environmental Research (CGER) , NIES
Cooperation : Isamu Morino Senior Researcher, Satellite Remote Sensing Research Section, CGER, NIES

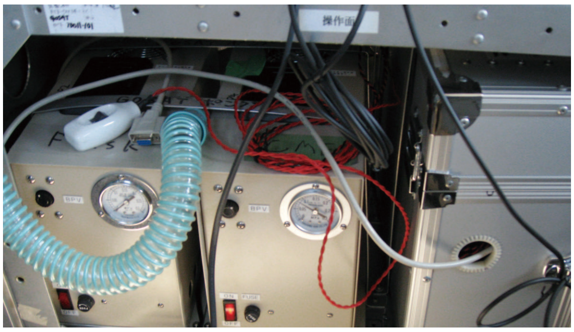
"IBUKI" observes the greenhouse gases in the earth atmosphere from space. To confirm the reliability of data is an important task in the project.

On February 14, 20, and 23 of this year, NIES GOSAT Project conducted an airborne observation as a part of the GOSAT data products validation in cooperation with Japan Aerospace Exploration Agency (JAXA), and measured the concentration of greenhouse gases in the atmosphere around Tsukuba area using instruments on an aircraft and a ground-based Fourier Transform Spectrometer (FTS).

The air at the altitude between 500m and 2000m was collected over Tsukuba City, and between 2000m and 7000m was collected over Kumagaya City where there is no flight regulation for that height. The air was taken into the plane, and 16 flask samples were collected. Onboard the aircraft was the Non-dispersive Infrared Analyzer which uses infrared absorption of CO_2 to measure the concentration of the CO_2 continuously while the samples were being collected. During the airborne observation, the direct solar radiation was measured on the ground in the Atmospheric Minor Constituents Spectra Observatory in the Climate Change Research Hall at NIES to obtain the concentration of the greenhouse gas over Tsukuba. "IBUKI"'s FTS observes the sunlight reflected by the surface of the earth as well as the radiation from the land and sea surface and the atmosphere to estimate the concentration of the greenhouse gas in the atmosphere. In this observatory at NIES, there is a similar FTS that retrieves the concentration of the greenhouse gas in the atmosphere right above Tsukuba by observing the direct sunlight. Additionally, sondes were launched from NIES to measure the weather conditions such as temperature, humidity, wind-direction and wind speed. There were ten other different observations carried out at once on February 20, 2010. These results are going to be analyzed, and the data will be used for "IBUKI"'s data validation.

As you may already know, "IBUKI" is unable to observe the greenhouse gas when there is a cloud. Fortunately, the observation on February 20 was conducted in the warm and clear weather. NIES Senior Researcher Isamu Morino was happy about the success of the airborne observation; "It is almost clear sky today and now we have a set of data under the observation condition with little chance of errors."

The member of the airborne observation in front of an aircraft at Komaki Airport, Aichi. Photo : Tomoaki Tanaka.

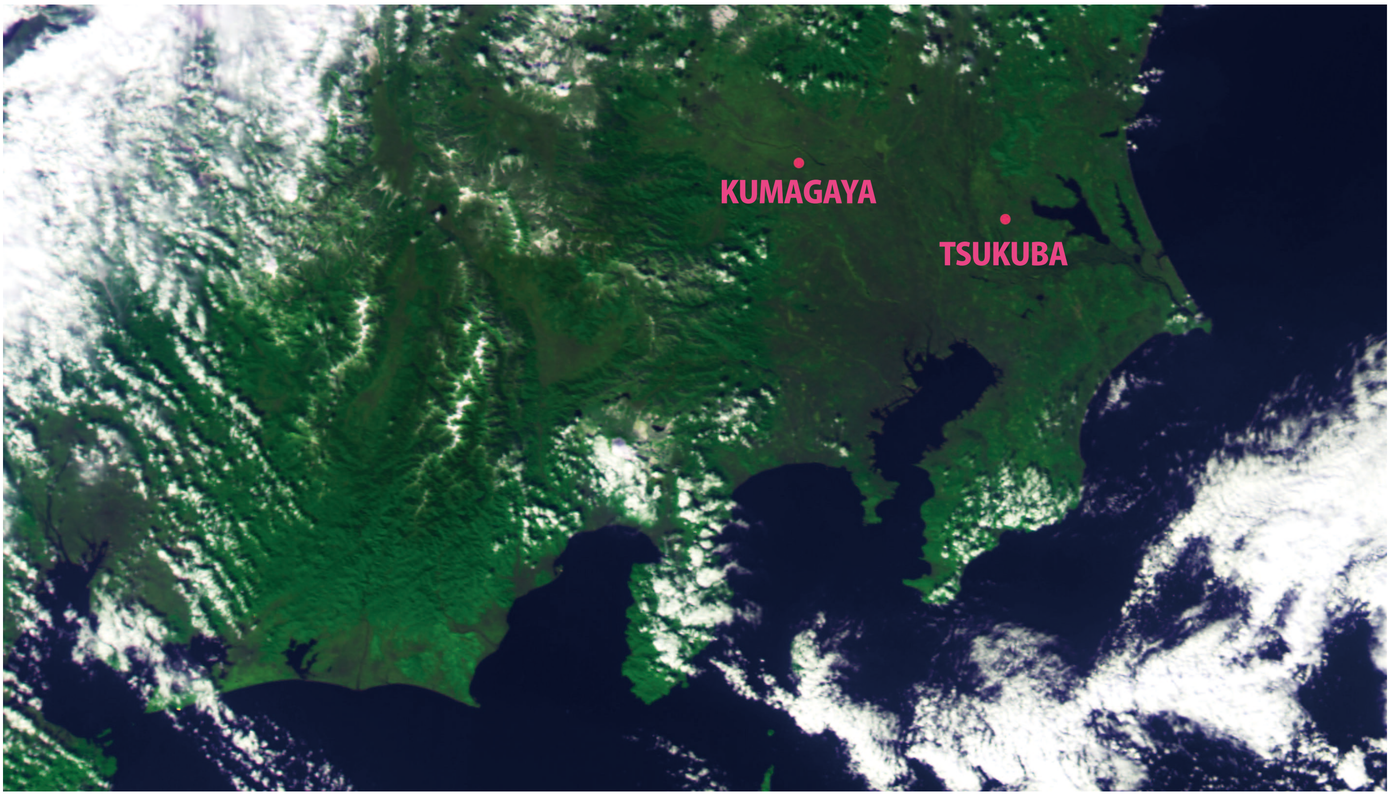


Instruments onboard the aircraft. (left, center) Pumps to compress the air taken in from the outside. (right) Equipment that measures the CO_2 concentration directly. Photo : Tomoaki Tanaka.

NIES Senior Researcher Isamu Morino demonstrates the high-resolution FTS installed in the Atmospheric Minor Constituents Spectra Observatory in the Climate Change Research Hall at NIES. The sunlight comes into the observatory through a hole on the roof, and then reflected by the gold mirror into the FTS. In the FTS, the spectrum of sunlight that was affected by the absorption by greenhouse gases is measured.

A sonde carrying sensors for GPS, temperature, humidity, wind direction, and wind speed measured the weather condition as high as 20 km.

GOSAT NEWS continued



CAI L1B+ data product showing the Kanto area acquired on February 20, 2010 during the airborne measurement for the GOSAT data products validation. There is no cloud over Tsukuba City and Kumagaya City where the airborne and ground measurements were conducted.
Blue = Band 1, Green = Band 3, Red = Band 2.

GOSAT INTERVIEW

DR. PETER RAYNER

Senior Expert, Laboratoire des Sciences du Climat et l'Environnement, France

Dr. Peter Rayner is a senior expert at Laboratoire des Sciences du Climat et l'Environnement in France, specialized in global carbon cycle and inverse modeling. Dr. Rayner is an extraordinary researcher not only for his globally acknowledged work, but also because he is totally blind. Last January during the 6th International Workshop on Greenhouse Gas Measurements from Space, Dr. Rayner sat down with NIES GOSTA PROJECT NEWSLETTER for an interview and talked about his personal history, and his involvement and expectation in the community of measurements of greenhouse gases from space. The interview was conducted in the presence of Tatsuya Yokota and Shamil Maksyutov in Kyoto, Japan, January 27, 2010.

"A little bit unusual as a scientist..."

I was born and brought up in Melbourne, Australia in the early 1960s. One thing a little bit unusual about me as a scientist is that at age one, because of the genetic condition, I became totally blind.

Ever since I could remember, I wanted to do research, originally physics. I used to read biographies of famous physicists when I was a child, and that is the kind of thing I wanted to do. When I was quite young I read a biography of Ernest Rutherford, the nuclear physicist who was born in New Zealand, which is 'almost' Australia. So I remember being impressed that he was active in the early twentieth century when it was not easy for somebody from 'the end of the world' to become established and famous in Britain.

I kept that ambition all through high school, which may be a bit unusual. The fact that I was blind made things a bit more difficult, but never so difficult that I thought about changing my mind. I think I always had the idea that if I could overcome and if I could get to university or if I could start to make a career, I could find a way of doing research. And, that turned out to be correct.

So, I started university and I was still studying physics. Towards the end of the degree, a very close friend of mine and I discussed what we should do next. Much of the use of physics was in the military that time in mid 1980's, but we did not really want to pursue that. Then, I remember him suggesting we can use the same kind of skills to study the earth and atmosphere. I thought "Well, we can try that for a while." So, we both changed on the same day to the same department. Ever since then, I've been involved in atmospheric sciences.

I started working in carbon cycle completely by accident. I was actually following my wife who wanted to do a Ph.D. in the US, and there was a job at the same place doing carbon cycle research. So in the early 1990s, I started to work on carbon cycle at Princeton University. I returned to Australia a few years later and got involved in the inverse modeling. I was following the footsteps of my chief at the time, Dr. Ian

GOSAT INTERVIEW continued

Enting. We realized that measurements that we had at that time were far too widely spaced, rare, and difficult to make estimates of sources and sinks. We needed to do something radically different to get a good picture of the sources and sinks of these important gases. This was the late 1990s, when the interest in finding other methods for doing this was really strong.

"Somebody in the audience said, "Could you do this for satellites? ""

I remember I was presenting mathematical techniques for locating new measurement stations to make the most cost-effective improvement that we could. Then, somebody in the audience said, "Could you do this for satellites?"

I didn't quite know what the question meant, because I had never heard of the idea of measuring CO_2 from satellites. It turned out actually that there had been work already in Japan, by Dr. Tadao Aoki[1] in the early 1990s. I think of him as a pioneer of these kinds of measurement, but at the time, I did not know how to do this test with satellites. After a few months, we finally had a calculation and it was clear that it was going to be a very major step forward.[2]

This was 1999 by then, and there was a strong interest from National Space Development Agency of Japan (it is now Japan Aerospace Exploration Agency(JAXA)) and NASA in flying missions. Japan had already done it with IMG (Interferometric Monitor of Greenhouse gas) instrument onboard the ADEOS satellite. People had the instinct for how useful these instruments might be, but it was very important to have a mathematical or quantitative estimate of how much information we can bring.

Suddenly, Dennis O'Brien and I, the two authors of the paper were quite in demand for attending the scientific events linked to the satellite community that I knew nothing about. So, one of the effects of this earlier work has been that a new community was formed for the measurement of CO_2. Then, there is always the very slow period of developing missions. Getting instruments approved and built takes much longer than a theorist like me thinks it should. Last year we had the first two launches. Unfortunately, OCO failed on the launch, but GOSAT is launched, and the information is starting to flow.

"Learning something from the satellites that we wouldn't have learned from the surface network."

Now we have learned in reality that this measurement is very hard because our accuracy requirements for the measurements of sources and sinks were much higher than what we had normally needed in the ordinary satellite measurements. However, watching the progress over the last year, I am more optimistic now in the end of this meeting than I had been for the last year. In the very near future, we will get a measurement that we can really use.

The measurement is really useful when we learn something from the satellites that we wouldn't have learned from the surface network. To me, that is the test of how good these satellites will be. The chance is pretty good, because so much of the interesting behavior in the carbon cycle is in the tropics where the surface network is very week. There has been a series of papers by Dr. Christian Frankenberg, who is now with NASA, working on CH_4 from SCIAMACHY. I think that is the first time we have learned something about greenhouse gas by measuring from space that we could not learn from the surface. We learned about some hot spots, strong emissions and emissions in the tropics. So, I believe we can have the same level of success with the better measurements of CO_2 from GOSAT. It can be a pioneer.

"The question is how to combine."

The other thing is the use of these measurements in comprehensive large simulation systems. There are measurements from the operational meteorological satellites, AIRS, IASI, TES, and SCIAMACHY. We can also get some information on the greenhouse gases from them. On their own, they are not so much use, but when you combine them with the measurements like GOSAT and SCIAMACHY, suddenly the information offered by the two instruments together becomes much stronger. Several research organizations around the world, including the one in Europe where I have been closely involved with in the last few years, have built systems to take in this range of measurements from different instruments at once, using similar techniques as we use in weather forecasting in numerical meteorology. The weather forecasting works so well because they combine the information from so many satellites. We now can do that for measurements of greenhouse gases as well. There are people from the European Center for Medium range Weather Forecasting (ECMWF) who are going to use GOSAT data along with measurements from AIRS and IASI, and even the measurements taken on the surface. I expect them to make a pretty big advance quite quickly.

"There's still some work to do."

In a long term, there is a question. The measurements like GOSAT provide the best measurements we have because they measure all the way through the atmosphere but they can't measure at night or in winter. There are techniques more expensive and more difficult, but they will allow us to measure everywhere all the time. It is a real question, what is the best way of spending our money on missions.

We can apply the same kind of mathematical techniques that we used ten years ago to test whether a satellite measurement of greenhouse gases was any use at all, to test if it is better to fly one expensive mission, or two less expensive missions together given the amount of money you have got. So there's still some work to do in testing the best possible combination that we can have.

1 Dr. Tadao Aoki (1943-2008) is one of the founding members of GOSAT mission, involved with the algorithm development at NIES GOSAT Project since 2004. Until then, Dr. Aoki was affliated with Meteorological Research Institute in Japan for 20 years. Dr. Aoki achieved numerous excellent works on the infrared spectroscopy that is at the base of infrared radiative transfer research, and the application of the infrared radiative transfer and remote sensing.

2 Rayner, P. J., and D. M. O'Brien (2001), The utility of remotely sensed CO_2 concentration data in surface source inversions, Geophys. Res. Lett., 28(1), 175-178.

GOSAT INTERVIEW

A Series: "IBUKI"'s PI Interviews

GOSAT Project hosted the Second Annual Research Announcement Principal Investigator Meeting (RA PI Meeting) in Kyoto from January 28 to January 29. At this meeting, the PIs of selected RAs, 133 of them from 18 countries around the world, gathered and had intensive discussions.

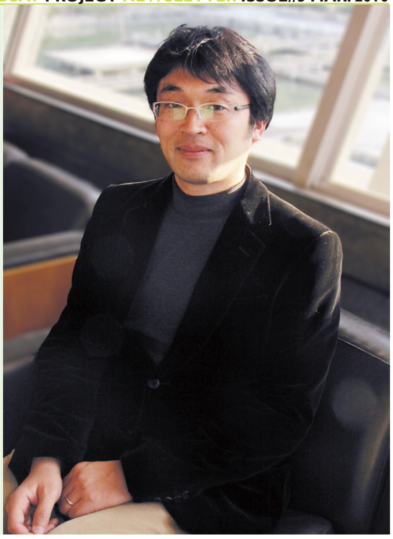
For this issue we are going to introduce one of the PIs from the second RA, Associate Professor Kazuhito Ichii of Fukushima University. (Interviewer: Yuki Tanaka. Kyoto, Japan. January 28, 2010.)

No.2

Associate Professor KAZUHITO ICHII

of

Faculty of Symbiotic Systems Science, Fukushima University, Japan



—Could you explain what your current research is on?

I am doing research on three topics right now. The first topic is on the model for global warming projection. To be exact, I am doing a research to improve the reliability of the future projection of climate change by using a model called Earth System Model that simulates the climate and carbon cycle among atmosphere, land, and ocean at once.

It is often said that among the global warming system, the land carbon balance contains a large uncertainty. Then this relates to the second topic of my research, to improve the terrestrial biosphere models that estimate the carbon exchange and vegetation distribution on the land surface. Carbon exists mainly as CO_2 in the atmosphere, but on the land surface it is absorbed into vegetation. After the plants die, carbon moves to the soil, and in the soil it is decomposed, and goes back to the atmosphere again. This is the cycle of carbon, and the terrestrial biosphere models simulate such carbon cycle on the land surface.

The third topic is something more local. I work for Fukushima University in Japan, so I analyze the land cover change in Fukushima Prefecture at its municipal level and the water cycle along the Abukuma River.

I spend most of the time working on the first two. My research is mainly on developing and improving the models for the climate change prediction at the continental and global scales..

—How did you get to where you are now?

I used to look at clouds and thought them mesmerizing, and I was interested in the weather. The climate change is a global issue, and I am attracted to big matters as such. I am from Anjo City in Japan, and as a child, I would play in the hills and fields, play baseball, play tags, collect bugs all day outside…

I studied geophysics at Nagoya University for my bachelor's degree. It did not have much to do with the climate change. I wanted to study meteorology at first, but the research lab that I belonged to was not doing research on that kind of topics. So, instead, I worked on simulating the period during the Banded Iron Formation when a layer of large amount of iron was formed 20 or 30 million years ago. In fact, I was not very enthusiastic about doing research then, so I started working at a company after graduation. This is by accident, but the company turned out to be now closely involved with GOSAT project. At that time, I worked for their remote sensing division. I took a part in satellite data application, in oceanic projects, and in one of the former Japanese satellite missions, Advanced Earth Observing Satellite ("Midori-II"(ADEOS-II)) This is how I met remote sensing. As I looked at so many images and analyzed the data, I started to think I wanted to do research, and I went back to school. So, I started my undergraduate program in 1991, and started working in 1995, and then I came back to Nagoya University for their graduate program in 1998. For my master's degree, I mainly studied remote sensing and how to apply the satellite data to the global warming models. I always thought remote sensing could be applied to many purposes. I remember there was a climate change related research that the U.S. National Oceanic and Atmospheric Administration satellites observed a great increase of photosynthesis of the vegetation in the middle to high latitude areas related to temperature increase. I thought I wanted to do research like this. So, that is how I started. Back then, the satellites and models were two different things, but I had an idea of going one step further and combining them.

—Please tell us about your research using "IBUKI"'s data.

What I am interested in the most about "IBUKI" is its Level 4A data products, the estimates of the CO_2 exchange of atmosphere-land and –ocean. One of the purposes of this satellite is to estimate the CO_2 exchange of the areas where the ground CO_2 measurement stations do not cover. Now that there are many more measurement points, I hope that the estimates will be more accurate. That is why I am interested in Level 4A data products. Using these data, I hope to improve the accuracy of the terrestrial biosphere models, and also the climate change prediction.

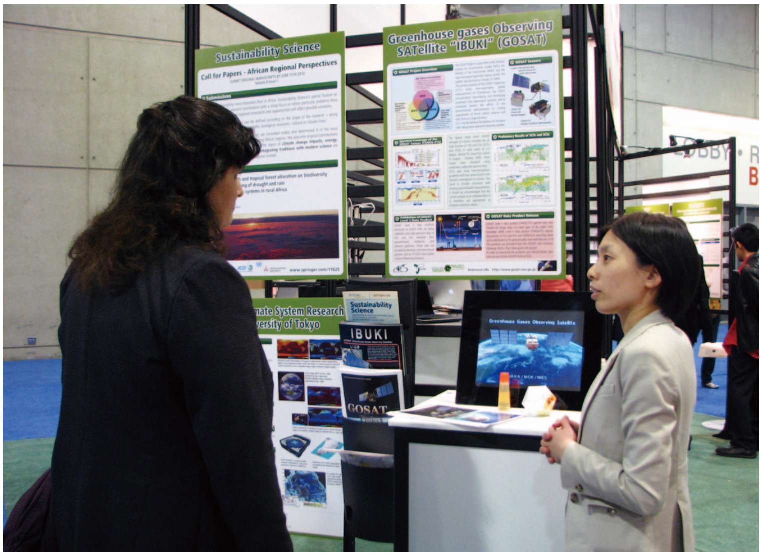
—What kind of research are you going to do from now?

First, I am going to focus on Asia, and want to get a clearer and more accurate picture of the carbon sink on the land surface in the East, South East, and South Asia. Carbon balance in these areas has not been uncovered so much yet. As a research, I hope to continue estimating the carbon sink using "IBUKI"'s data and also the existing terrestrial biosphere models, and at the same time I would like to contribute to the enhancement of the models' reliability. Then, after contributing to the enhancement of the models, I hope to continue using "IBUKI"'s data to understand how much they affect in predicting the climate change ultimately.

Associate Professor Kazuhito Ichii's research lab website :
http://envmm.jp

The AAAS Annual Meeting Report

— Yoshie Maeda, Project Researcher, The Integrated Research System for Sustainability Science (IR3S), The University of Tokyo



(right) IR3S Project Researcher Yoshie Maeda explaining GOSAT Project at the AAAS Annual Meeting. Photo : Courtesy of Yoshie Maeda.

In February 2010, Japan Science and Technology Agency, RIKEN, and IR3S of the University of Tokyo hosted a joint booth at the American Association for the Advancement of Science (AAAS) Annual Meeting (February 18-21, 2010 in San Diego, USA) to exhibit current scientific studies in Japan. National Institute for Environmental Studies, as a cooperative organization of IR3S, presented GOSAT Project as one of their major on-going projects. Reflecting the wide range of topics addressed at the meeting, the backgrounds of the visitors were also of great variety. Some of the visitors considered "IBUKI" satellite one of the contributions by Japan in the climate change research. There were also visitors who were interested in the recently released Level 2 data products, and took brochures in hand.

AHA! OF THE MONTH

Atmospheric Tracer Transport Model

Used in Inverse Modeling

— Hiroshi Takagi
Specialist, CGER, NIES

The Level 2 data products of "IBUKI" show the spatial and temporal variations of CO_2 on a global scale, but they are not direct indicators of how much CO_2 was emitted through human activities and how much the gas was taken up or released by the ocean and forests. Regional emissions and absorptions of CO_2 are inversely estimated from the Level 2 data products by using a computer program called "atmospheric transport model" that can simulate the global movement of CO_2 by the wind. This estimation method is called "inverse modeling."

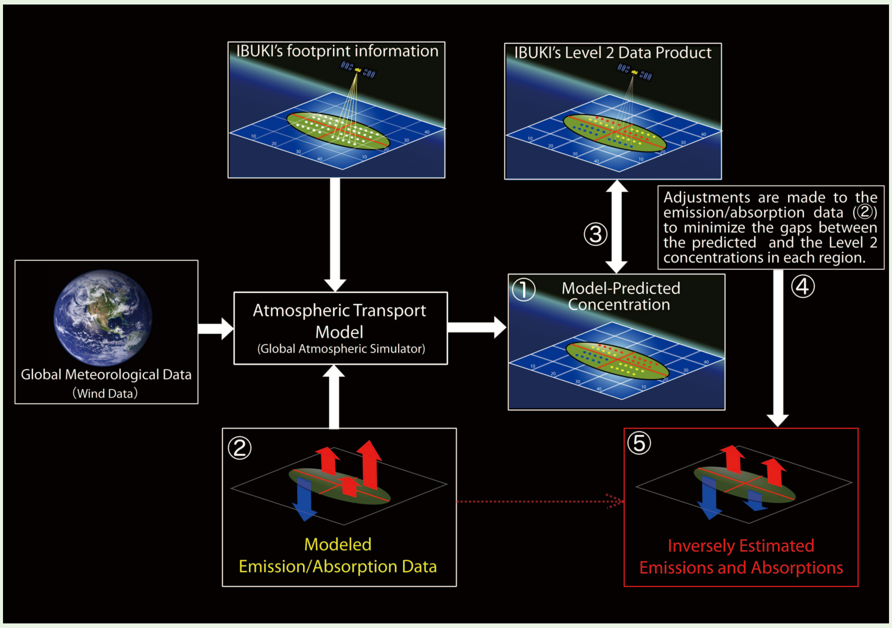


Figure: Flowchart of inverse modeling using "atmospheric tracer transport model" and "IBUKI"'s Level 2 data products.

The role of the atmospheric transport model in the inverse modeling is to predict CO_2 concentrations along the footprint of "IBUKI" (① in the figure) based on global meteorological data and modeled emission/absorption data (②). Although the transport model does quite well in predicting the concentrations, there are some differences between the predicted and the Level 2 concentrations (③). These gaps, however, can be minimized by "tweaking" the modeled emission/absorption data used to calculate the predicted concentrations as follows. In a region where the predicted concentration is lower than the Level 2 value, the region's CO_2 emissions are increased (or the absorptions are decreased). In another region where the predicted concentration is higher than the Level 2 value, the CO_2 emissions are decreased (or the absorptions are increased). This adjustment of the modeled emission/absorption data is carried out mathematically in the inverse modeling (④). The outcomes, which are the modeled emission/absorption data adjusted to match the Level 2 CO_2 concentrations, are the emissions and absorptions estimated via the inverse modeling (⑤). The modeling research scientists in the NIES GOSAT Project will estimate source/sink strengths in 64 global regions on a monthly basis, using the IBUKI's Level 2 data products combined with the ground-based observational data. The results will be released in 2011 as the Level 4 data product.

DATA PRODUCTS UPDATE

Data Processing Status Update from GOSAT Project Office

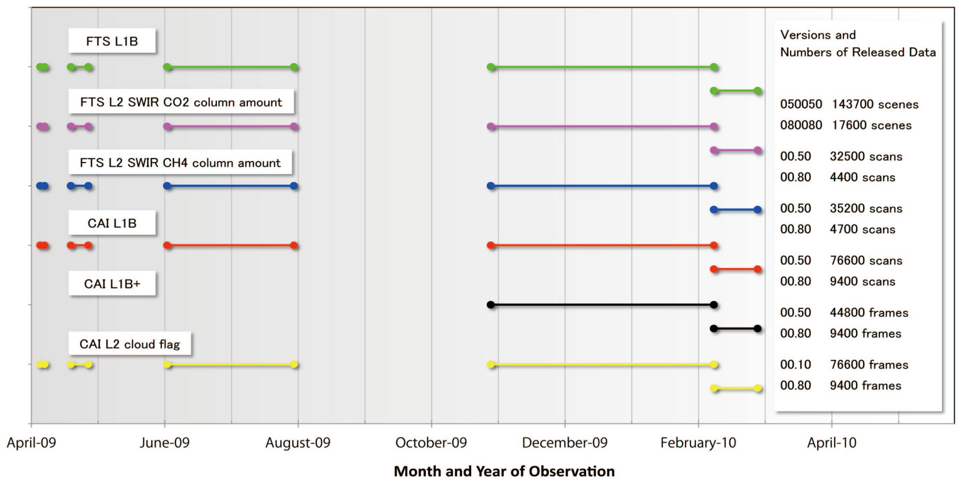
— Hiroshi Watanabe, NIES GOSAT Project Office Manager

Starting this issue, GOSAT Project Office would like to bring you monthly updates on "IBUKI"'s standard data products available to the public. This time, we would like to explain some basic facts, which are necessary for you to understand the upcoming articles of this newsletter.

The following six types of "IBUKI"'s standard data products are currently available to the public. The data are distributed in different units noted in parenthesis.

1. FTS L1B (Scene: FTS data for one revolution are divided into 60 scenes, each of which normally includes more than 20 scans)
2. FTS L2 SWIR CO_2 column amount (Scan: observation data of FTS, whose normal duration is four seconds)
3. FTS L2 SWIR CH_4 column amount (Scan : same as above)
4. CAI L1B（Frame: CAI data for one revolution are divided into 60; but actually there are only 31-32 frames since the CAI data are acquired only during the day time）
5. CAI L1B+ (Frame : same as above)
6. CAI cloud flag (Frame : same as above)

Observation Period and Versions of Publicly Released Data as of 2010/02/28



"IBUKI"'s nominal operation started in April, 2009, and Level 1 data products have been released to general users since November, 2009, and Level 2 data products, since February 2010. The left figure shows how many data have been released so far. Even though there are different versions, the numbers indicate those processed by the latest processing algorithm. We would like to explain each version in more details in coming issues of the newsletter. As many as 667 people have registered as general users as of March, 18, 2010, and the number is increasing everyday.

CALENDAR

2010/03/30-2010/04/01
Attending "WMO-BIPM Workshop on Measurement Challenges for Global Observation Systems for Climate Change Monitoring: Traceability, Stability and Uncertainty." held at the WMO headquarters in Geneva, Switzerland.

2010/04/17
Lecturing and exhibiting a booth at NIES Spring Environmental Lecture held as a part of the Science and Technology Week in Tsukuba city.

2010/05/02-2010/05/07
Presenting a research at European Geosciences Union (EGU) General Assembly in Vienna, Austria

INFORMATION

NIES Spring Environmental Lecture Information

On April 17, 2010, NIES is opening up the main research facilities to the public to introduce our daily research efforts as a part of the Science and Technology Week. GOSAT Project is going to hold lectures and exhibitions as well. We are looking forward to seeing you all.

"Koko ga Shiritai Ondanka" Lecture："Let's look at the Earth breathing from a satellite!"—Tatsuya Yokota
Location : Meeting Room1, Climate Research Hall (Lecture 20 min. Q&A 10min.)
Time：11:30〜12:00 and 14:30〜15:00
A lecture on satellite observation regarding "IBUKI"'s Level 2 data products (concentration of CO_2 and CH_4) that have been released publicly since February.

Exhibition: "Get to know about Greenhouse gas Observing Satellite"IBUKI" (GOSAT)"
Location：Exchange Meeting Room, Climate Research Hall
Researchers will introduce the current status of climate change research. The exhibitioin will include a model of"IBUKI," a spherical screen display of "IBUKI" data and simulation results, and a sensor similar to the Fourier Transform Spectrometer (FTS) onboard "IBUKI."

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