

# **Carbon Cycle and Satellite Data Contribution to the Global Stocktake and beyond ...**

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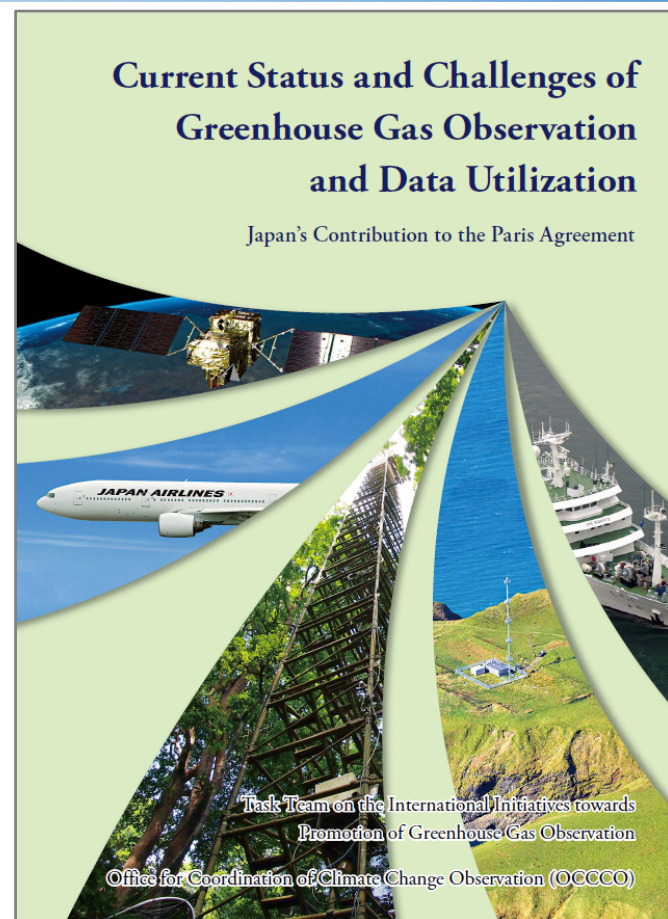
# Current Status and Challenges of GHG Observation and Data Utilization

## Japan's Contribution to the Paris Agreement

Provide Earth Observation (EO)-based data and knowledge of sink and source distribution of GHGs in support of the improvement of GHG inventories

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# Ground-based Monitoring

## Atmospheric concentrations of GHGs at near-ground levels

The National Institute for Environmental Studies (NIES) conducts monitoring of the atmospheric GHGs such as CO<sub>2</sub> at Cape Ochiishi, Hokkaido, Hateruma Island, Okinawa, and the summit of Mt. Fuji. NIES analyzes the variations in mixing ratios and isotope ratios of GHGs and other related atmospheric species, and provide monitoring data on its website (<http://db.cger.nies.go.jp/portal/>) and on WDCGG.



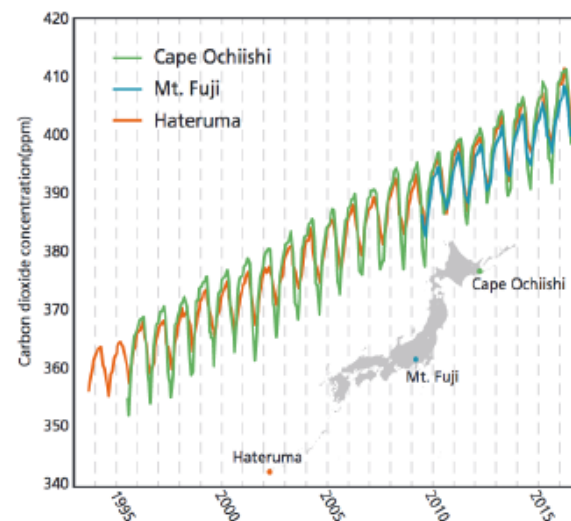
Monitoring station, Cape Ochiishi



Monitoring station, Hateruma



Mt. Fuji automated weather station



Annual variations in CO<sub>2</sub> concentration

Hateruma: CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, CO, H<sub>2</sub>, O<sub>2</sub>/N<sub>2</sub>, NO<sub>x</sub>, SO<sub>x</sub>, O<sub>3</sub>, CFCs, Rn, aerosol, <sup>14</sup>C, halocarbon, SF<sub>6</sub>, POPs

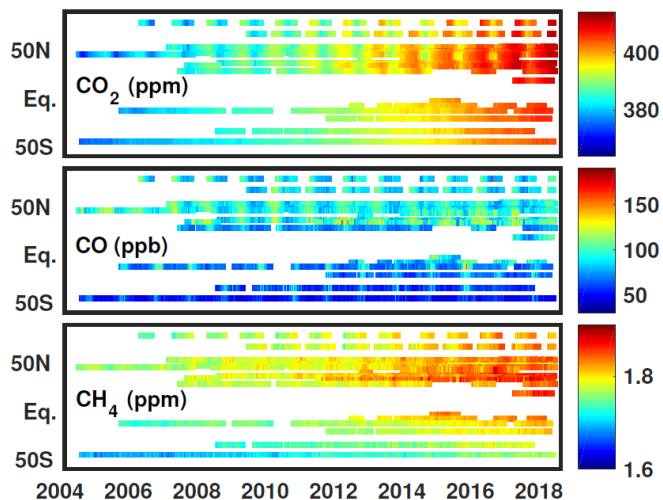
Data → WDCGG/GAW  
<https://gaw.kishou.go.jp/>



# Ground-based Monitoring

## Column-averaged concentrations of GHGs

Total Carbon Column Observing Network (TCCON) is a ground-based observation network for column-averaged concentrations of GHGs (averaged concentrations from the surface of the earth to the top of the atmosphere), and provides an essential validation resource for the satellite-based GHG observation as well as modeling.



Atmospheric CO<sub>2</sub>, CO, and CH<sub>4</sub> concentrations observed by TCCON

## High-resolution FTS at Rikubetsu TCCON site



<http://www.tccon.caltech.edu/>



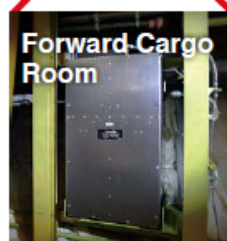
# Airborne-based Monitoring

The CONTRAIL (Comprehensive Observation Network for Trace Gases by Airliner) project is conducted by NIES, Meteorological Research Institute, Japan Airlines (JAL), JAMCO and JAL Foundation. The project observes CO<sub>2</sub> and other greenhouse gases by Continuous CO<sub>2</sub> Measuring Equipment and Automatic air Sampling Equipment onboard Boeing 777 aircraft operated by JAL. By using commercial airliners flying regularly, the frequency and geographical coverage of observations have been significantly improved.

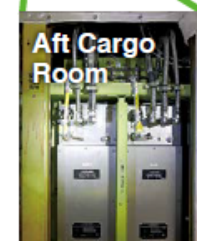
(CONTRAIL <http://www.cger.nies.go.jp/contrail/>)



Observation routes



Continuous CO<sub>2</sub> Measuring Equipment

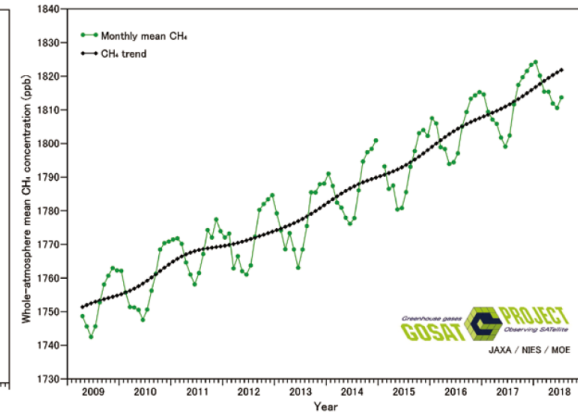
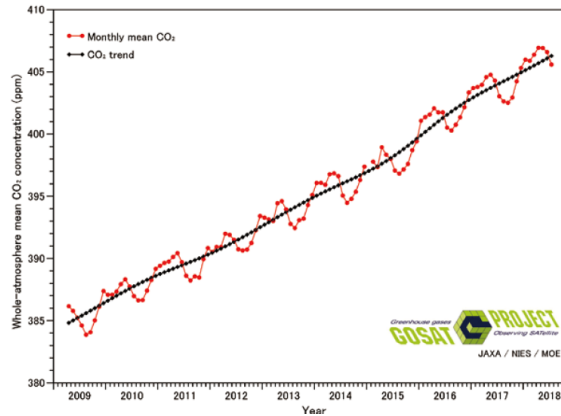


Automatic Air Sampling Equipment

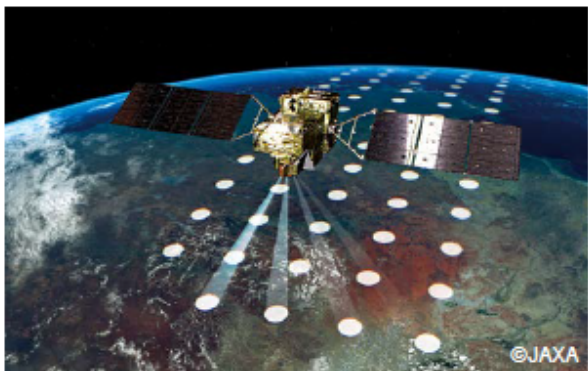
# Satellite-based Monitoring



GOSAT



Whole-atmosphere monthly mean CO<sub>2</sub> and CH<sub>4</sub> concentrations based on GOSAT



GOSAT-2

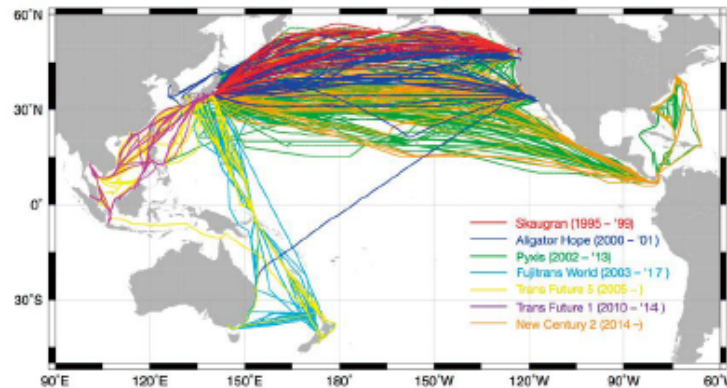


**GOSAT-2 was successfully launched on Oct. 29, 2018.**

# Ship-based Monitoring

NIES has implemented GHG and ocean surface CO<sub>2</sub> monitoring in the Pacific using volunteer observing ships since 1995. The observed data are published through the international database, SOCAT, and contribute to the evaluation of air-sea CO<sub>2</sub> exchange and to the examination of ocean acidification.

Parallely, NIES also has carried out observations for atmospheric GHGs and related species on the Japan-south eastern Asia route, in order to understand the temporal variations of atmospheric tracer gases and their emissions from Asian countries.



Observation routes



Trans Future 5



<https://www.socat.info/>

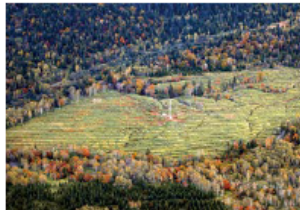


# Upscaling Terrestrial Carbon and GHG Fluxes

## Monitoring of GHG flux in terrestrial ecosystems using Eddy Covariance flux towers and their network



Fuji-Hokuroku, Japan (NIES)



Teshio, Japan  
(Hokkaido Univ., NIES)



Takayama, Japan (AIST)



Sakaerat, Thailand (AIST)



Automated chambers for soil efflux monitoring at Pasoh, Malaysia (NIES)



Mae Klong, Thailand (AIST)



Poker Flat Research Range Flux Observation Supersite in Alaska, USA (JAMSTEC, IARC)

Monitoring of GHGs such as  $\text{CO}_2$  and  $\text{CH}_4$  in terrestrial ecosystem has been started in 1993 by the National Institute of Advanced Industrial Science and Technology (AIST), NIES, FFPRI, National Agriculture and Food Research Organization (NARO), JAMSTEC and other research institutes and universities in Japan using micrometeorological methods such as the eddy covariance method. Monitoring of soil efflux has also been conducted using automated chambers. NIES has been conducting soil warming experiments at 10 forest sites to evaluate the ecosystem response to climate change. “AsiaFlux” is a regional research network under FLUXNET, and NIES supports the secretariat office.

Location of AsiaFlux-registered flux monitoring sites (<http://asiaflux.net>)



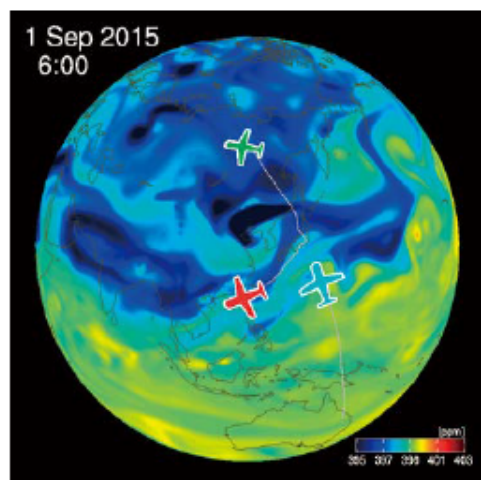
Forest, Plantation Fruit farm Paddy, Meadow, Crops  
Grassland, Wetland, Shrub, Steppe, Tundra, Desert Urban



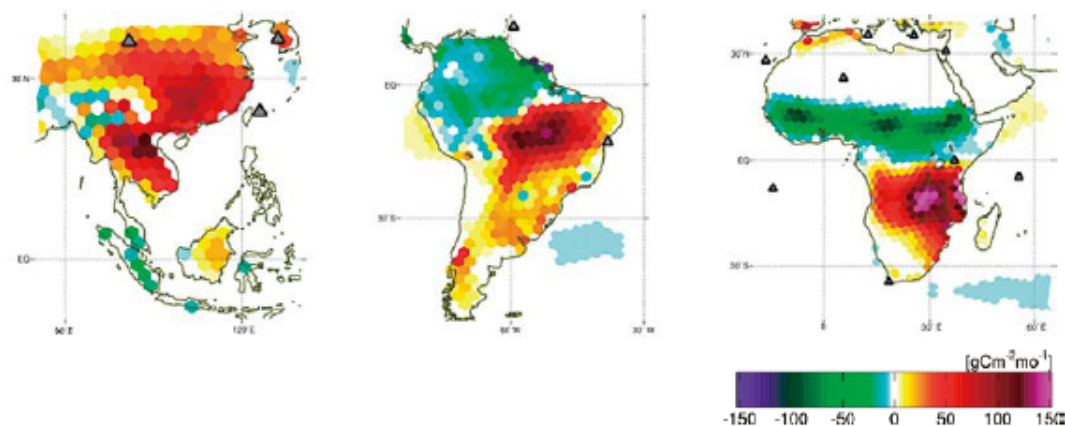


# Data Integration and Inverse Model Estimation for GHG Sources and Sinks

To develop integrated observation and analysis systems, atmospheric transport models and inverse systems are being developed and improved for estimating regional to global-scale GHG fluxes. Intermittent large-scale emission such as from a forest (peat) fire or from an agricultural field is one of the essential targets.



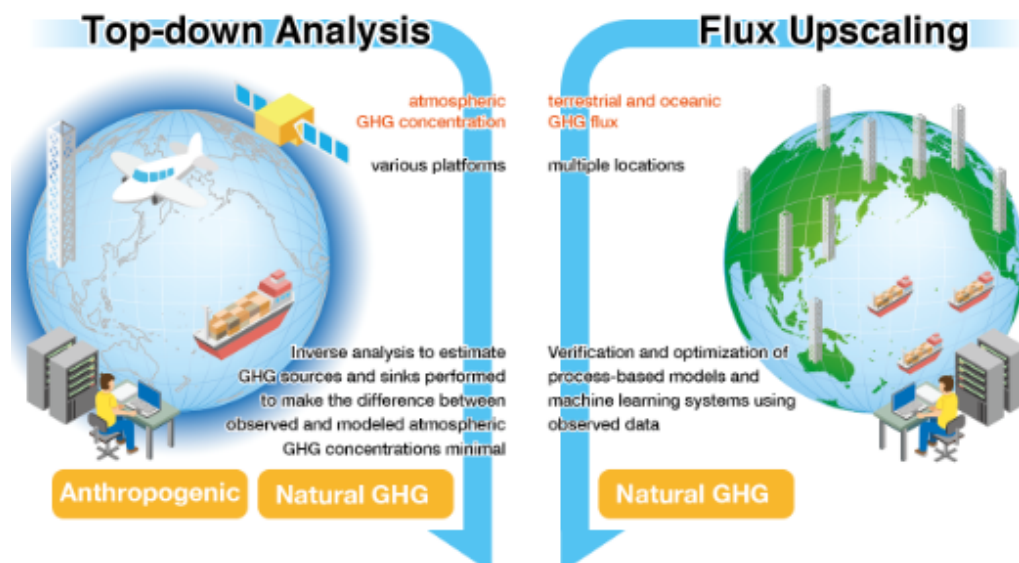
Atmospheric CO<sub>2</sub> concentration fields simulated by an atmospheric transport model "NICAM-TM"



Surface CO<sub>2</sub> fluxes estimated by a trial experiment with a new atmospheric GHG inverse system named NICAM-TM 4D-Var. The figures show monthly mean CO<sub>2</sub> flux distributions, focusing on regional anomalies due to biomass burnings for southeast Asia in March (Left), South America in September (Mid), and Africa in September (Right), which are generated from pseudo observations.

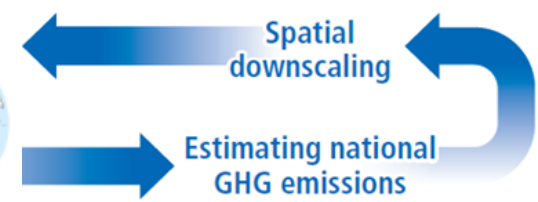
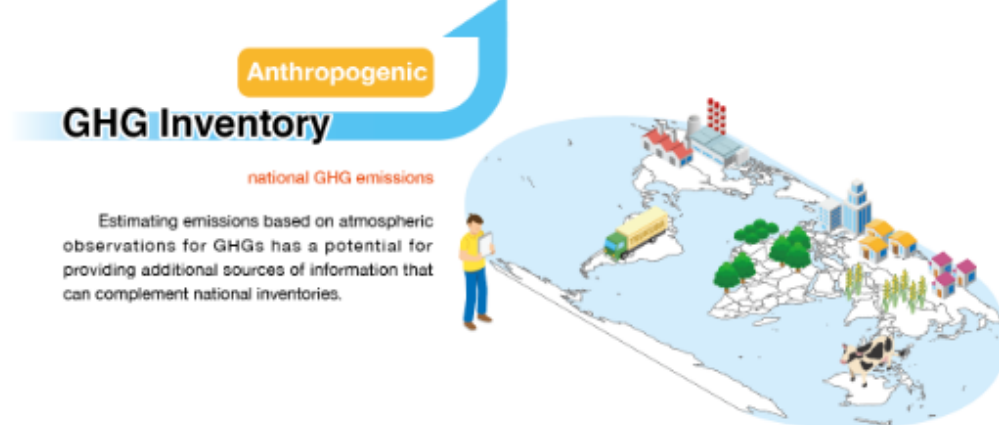
(Niwa et al., 2017)

# Providing Additional Information to Complement National Inventories



- 1) Top-down Analysis with Inverse Models to Estimate GHG Sources and Sinks
- 2) Flux Upscaling with Oceanic and Terrestrial GHG Flux Monitoring Data
- 3) Improvement of the Reliability of GHG Inventory Data

## Evaluation of sources & sinks



# Contribution to the Paris Agreement

- Estimating emissions based on EO for GHGs
- Providing additional sources of information that can complement national inventories
- Targets: Emissions from **expanding megacities**, intermittent emissions from **agricultural fields and forest (peat) fires**, and emissions from **large-scale land-use change**

Relevant Japanese institutions and agencies for GHG observation and analysis will cooperate to improve analysis systems and data coverage for better estimation of emission distributions with sufficient accuracy, and to provide the data and knowledge to stakeholders in time with the Global Stocktake Process.

# Why GHG - AQ collaboration?

- Interaction of Air Quality & Climate Change
  - Impacts of air quality on climate change (i.e., [SLCP](#))
  - Impacts of climate change on air quality (i.e., [adaptation](#))
  - Both air quality & climate change affect [human health](#)
- Co-benefit in Environmental Policy
  - CCAC ([Climate](#) and [Clean Air](#) Coalition)
- Better quantification of anthropogenic emissions
  - GHGs and air pollutants are co-emitted from “[combustion](#)” sources
- Advancing our understanding of “Atmospheric Composition” and improving “common” analytical tools in the community
  - Modeling, emission inventory, sensors, etc



# Impacts of Air Pollution on Human Health

**More people die from air pollution than Malaria & HIV**



## Air pollution and health

From smog hanging over cities to smoke inside the home, air pollution poses a major threat to health and climate. The combined effects of ambient (outdoor) and household air pollution cause about 6.5 million premature deaths every year, largely as a result of increased mortality from stroke, heart disease, chronic obstructive pulmonary disease, lung cancer and acute respiratory infections. More than 80% of people living in urban areas that monitor air pollution are exposed to air quality levels that exceed WHO guideline limits, with low-and middle income countries suffering from the highest exposures, both indoors and outdoors.



[More about air pollution](#)

**3 million**

deaths every year as a result of exposure to ambient (outdoor) air pollution

**4.3 million**

deaths every year as a result of household exposure to smoke from dirty cookstoves and fuels

**92%**

of the world's population lives in places where air quality exceeds WHO guideline limits

NEWS | ENVIRONMENT 27 SEPTEMBER 2016

## WHO: 90 percent of world's population breathe dirty air

*UN body's new report blames air pollution for global "health emergency" killing millions per year.*



ALJAZEERA



Air pollution is most acute in cities, but the problem in rural areas is worse than many think [AP]

SUSTAINABLE DEVELOPMENT GOALS

# So Far... at NIES

Natural Carbon  
Cycle Flux

- Satellite
- Surface, aircraft
- Inverse modeling

Anthropogenic  
Carbon  
Emissions

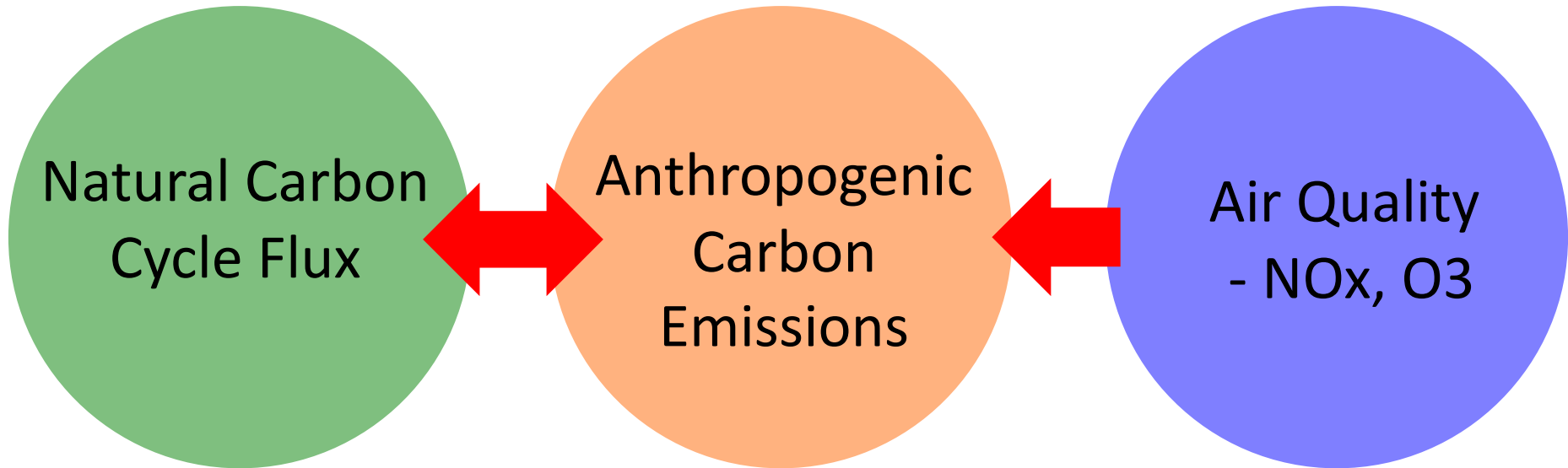
- Assumed to be KNOWN

- NOT KNOWN!!
- RAPIDLY CHANGING!!
- TO BE REDUCED!!

Air Quality  
- NO<sub>x</sub>, O<sub>3</sub>

- Satellite
- Surface, aircraft
- Inverse modeling

# Now ... New Target



- Satellite
- Surface, aircraft
- Inverse modeling

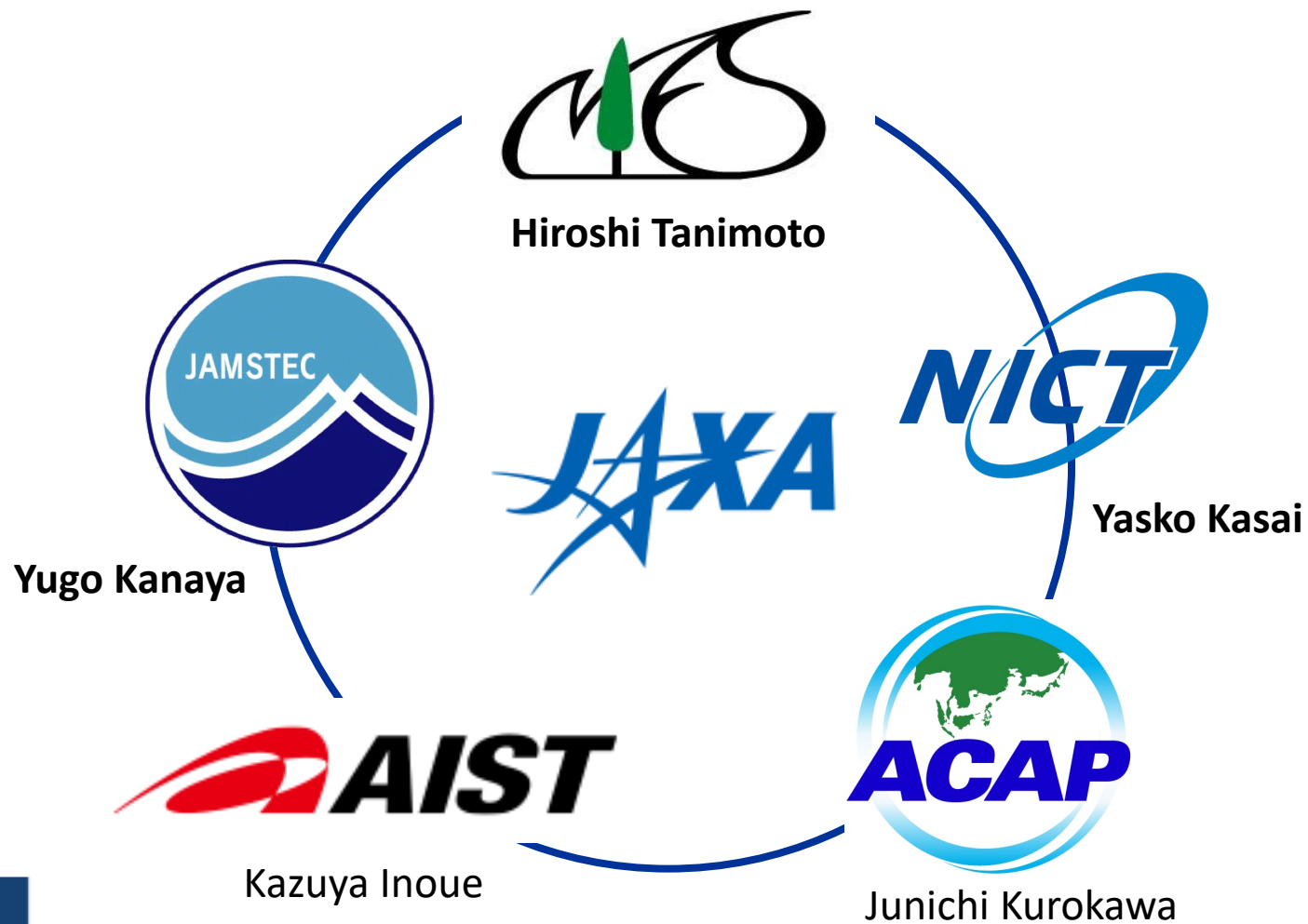
- Paris agreement
- NDCs
- Nat'l/city-scale inventory

- CCAC - SLCP
- IPCC AR6 - SLCP
- Assimilation, OH

## Policy Implementation

- Actionable targets for policymakers
- Global stocktake 2023

# Inter-Agencies Team toward Integrated GHG/AQ Approach



**Jet Propulsion Laboratory**  
California Institute of Technology

Kazu Miyazaki



**Universität Bremen**



**USRA**

Tom Oda



# Quantifying Combusted Carbons from Cities for Climate Change Mitigation: The Megalopolis Tokyo GHG-AQ (MegalTokyo) Project

*19<sup>th</sup> GEIA Conference, November 2019*

**Hiroshi Tanimoto (Co-lead), Tomohiro Oda (Co-lead)**

NIES: Y. Terao, M. Nishihashi, Y. Tojima, M. Saito, R. Cong, A. Ito, S. Maksyutov

JAMSTEC: Y. Kanaya

Institute of Behavioral Sciences: T. Fukui

JMA: M. Ueno

Osaka University: T. Hayashida, T. Machimura

LSCE: T. Lauvaux

WMO/IG3IS: P. DeCola

# Summary

- As a national laboratory of the environment in Japan, NIES has played and is playing an important role in the [earth observation](#) and [carbon cycle](#) communities, including CEOS, by providing [GOSAT data](#)
- NIES is willing to enhance its commitments and leadership by strengthening the activities aiming the [GHG - AQ synergetic effects](#)
- These efforts will be made in satellite obs., modeling, and emission inventory, and [integrated analysis](#) by making use of these tools
- In particular, for [GOSAT-3](#) to come