Monitoring of atmospheric methane from GOSAT over Monsoon Asia

S. Hayashida

Nara Women's University

Acknowledgement: We thank to NIES GOSAT team for providing us the GOSAT retrieval products. We also thank to Dr. Terao (NIES), Dr. Mukai for their efforts on air-sampling and chemical analysis of the samples.
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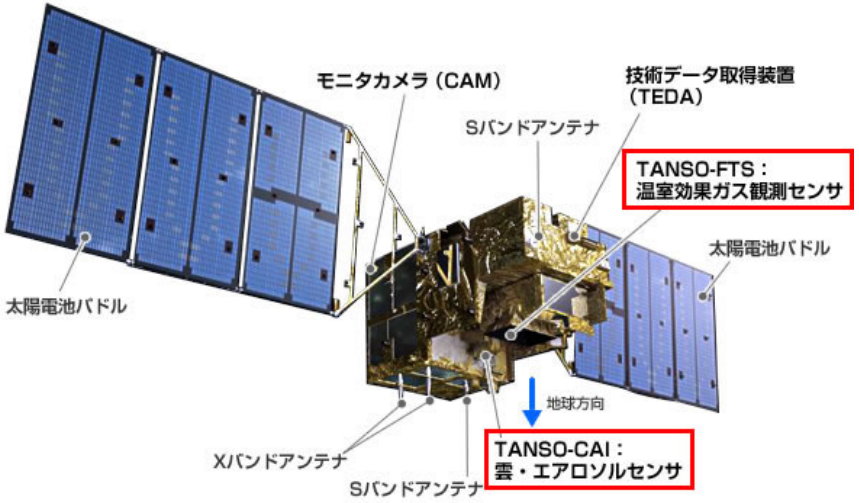
GOSAT measures Methane

GOSAT, Greenhouse gases Observing SATellite “IBUKI ,” was launched on 23 Jan. 2009.

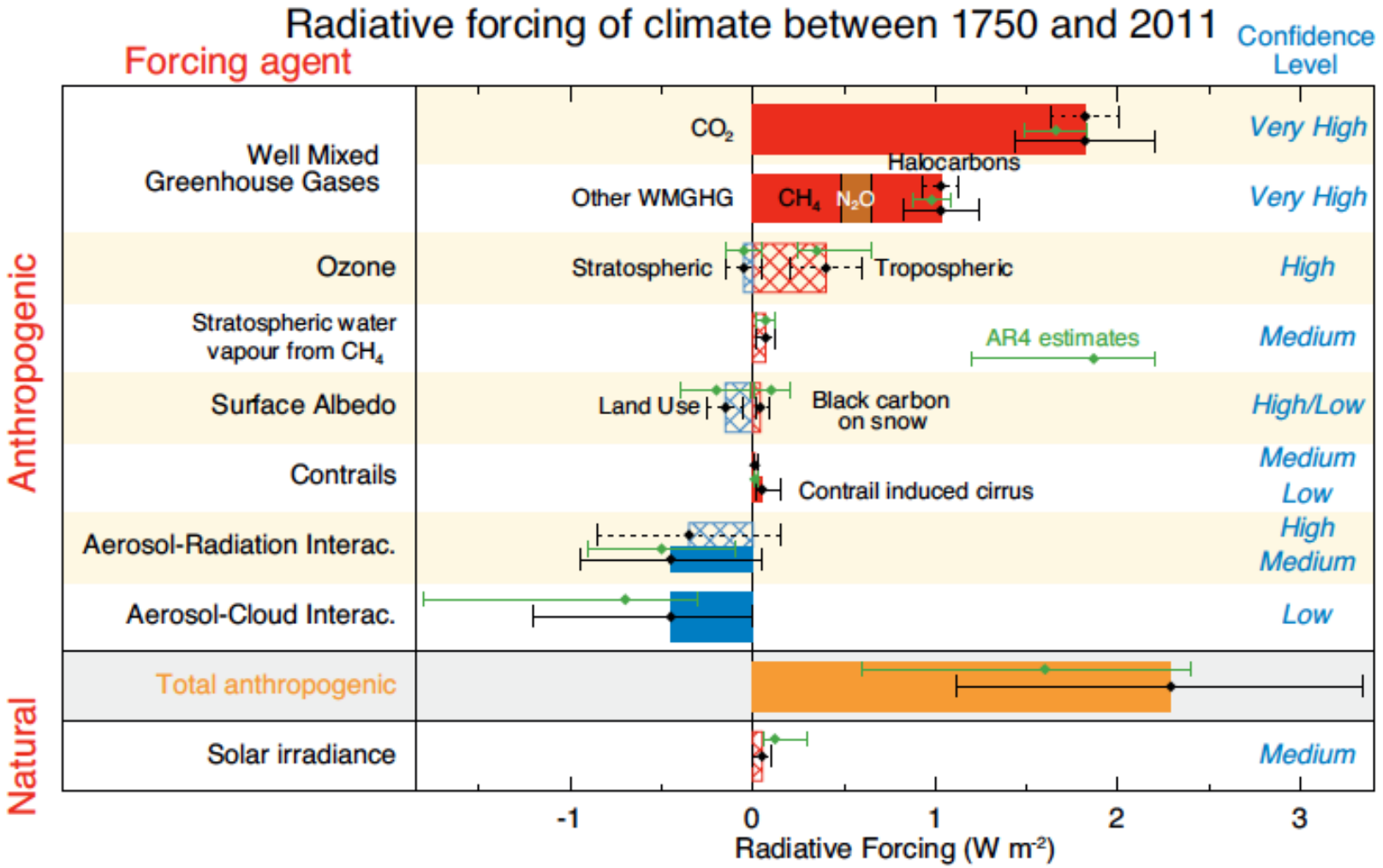
TANSO-FTS accumulated 5-yr record

The first/only satellite dedicated to greenhouse-gas-monitoring.

Target: CO_2, CH_4 IFOV: 10.5km in diameter, 3-day recurrent orbit with 3(or 5) point mode



Methane (CH_4): Radiative forcing is the second largest after CO_2



What are Short-Lived Climate Pollutants?

Short-lived Climate Polutants	ANTHROPOGENIC SOURCES	LIFETIME IN ATMOSPHERE	LOCAL / REGIONAL / GLOBAL IMPACTS / MITIGATION
Near term response to mitigation			
Black Carbon (BC)		Days	● ○ ⊕
Methane (CH_4)		12 years	• ○ ⊕
Tropospheric Ozone (O_3)		Weeks	● ○ ⊕
Hydrofluoro-carbons (HFCs)		15 years (Weighted by usage)	⊕
Long-lived Climate Pollutants			
Longer term response to mitigation			
Carbon Dioxide (CO_2)	Rapid, deep, and persistent cuts in CO_2 and other long-lived greenhouse gases are necessary to stabilise global temperature rise in the long term.	Up to 60% <100 years Up to 25% >1,000 years	⊕

SLCP IMPACTS

- Harm public health
- Reduce food security
- Warm the atmosphere
- Increase ice and snow melting
- Disrupt weather patterns

CCAC

Methane (CH_4)

Methane emissions caused by human activities are one of the most significant drivers of climate change. Methane is also the main precursor of tropospheric ozone, a powerful greenhouse gas and air pollutant.

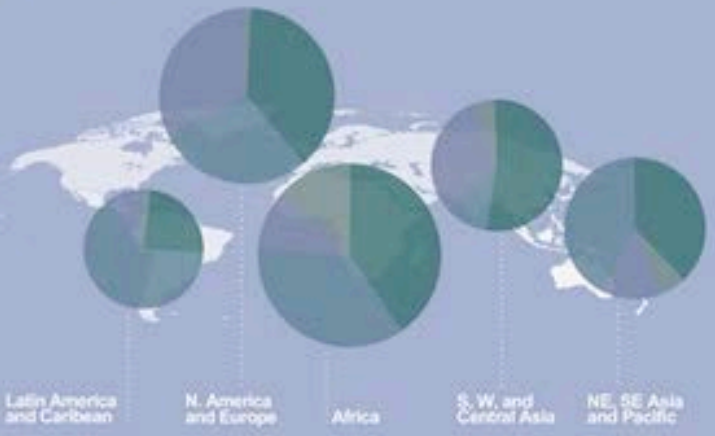
LIFETIME IN ATMOSPHERE

12 years

CH_4 is a powerful GHG contributing to **global warming**

EMISSIONS

and main sources by region and sector (2005)



Major anthropogenic **SOURCES** (60% of methane emissions come from human activities)

310 Mt Global CH_4 **anthropogenic emissions** in 2005

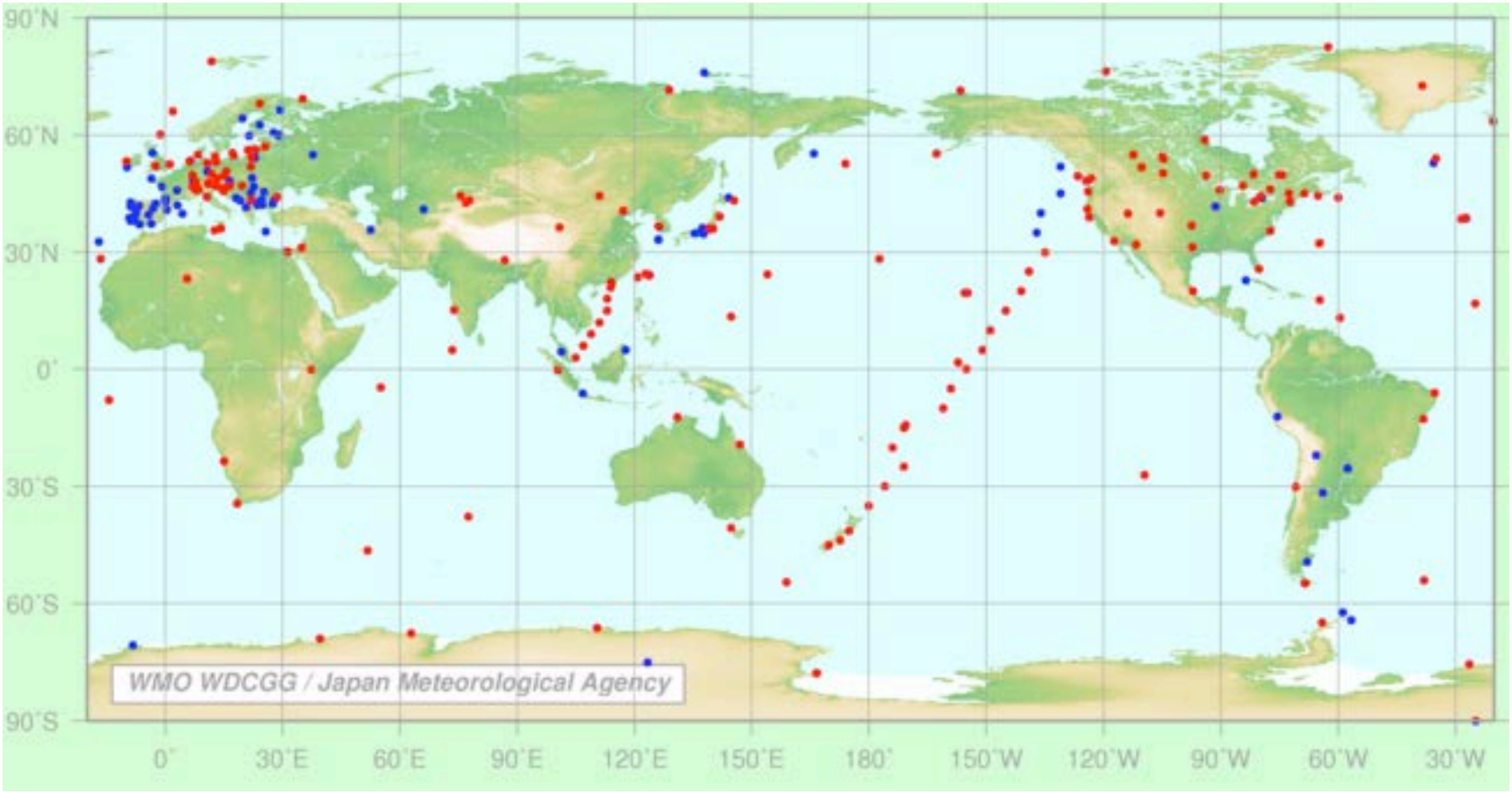
IMPACTS

Globally, increased methane emissions are **responsible for half of the observed rise in O_3 levels**

While methane does not cause direct harm to human health or crop production, its role **as precursor gas contributes greatly to the health and agricultural impacts of O_3**

CCAC

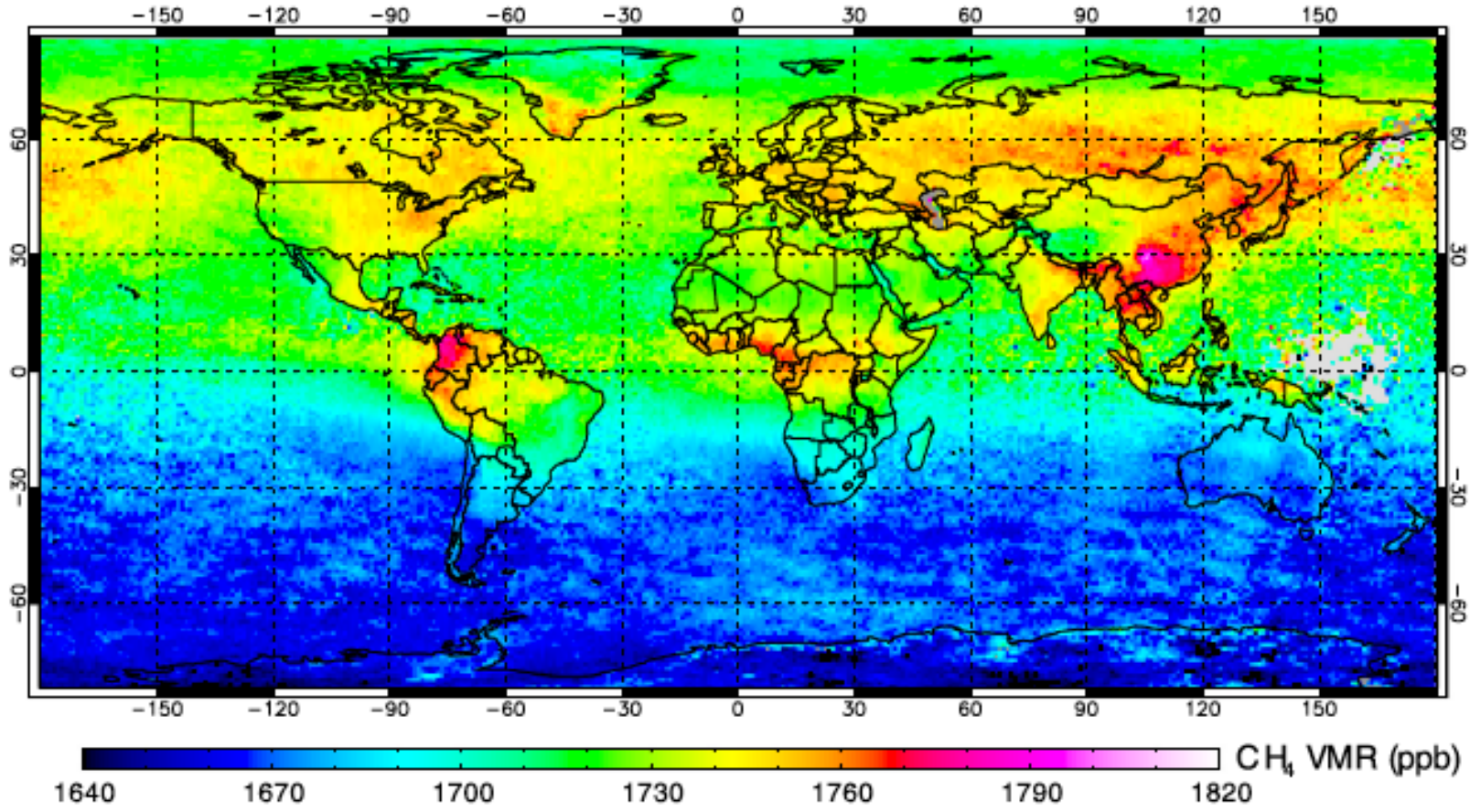
The current observational network: insufficient coverage



WDCGG http://ds.data.jma.go.jp/gmd/wdcgg/

Atmospheric methane measurements at ground-based Network have revealed "background level" but NOT source regions -> Now satellite observation is available

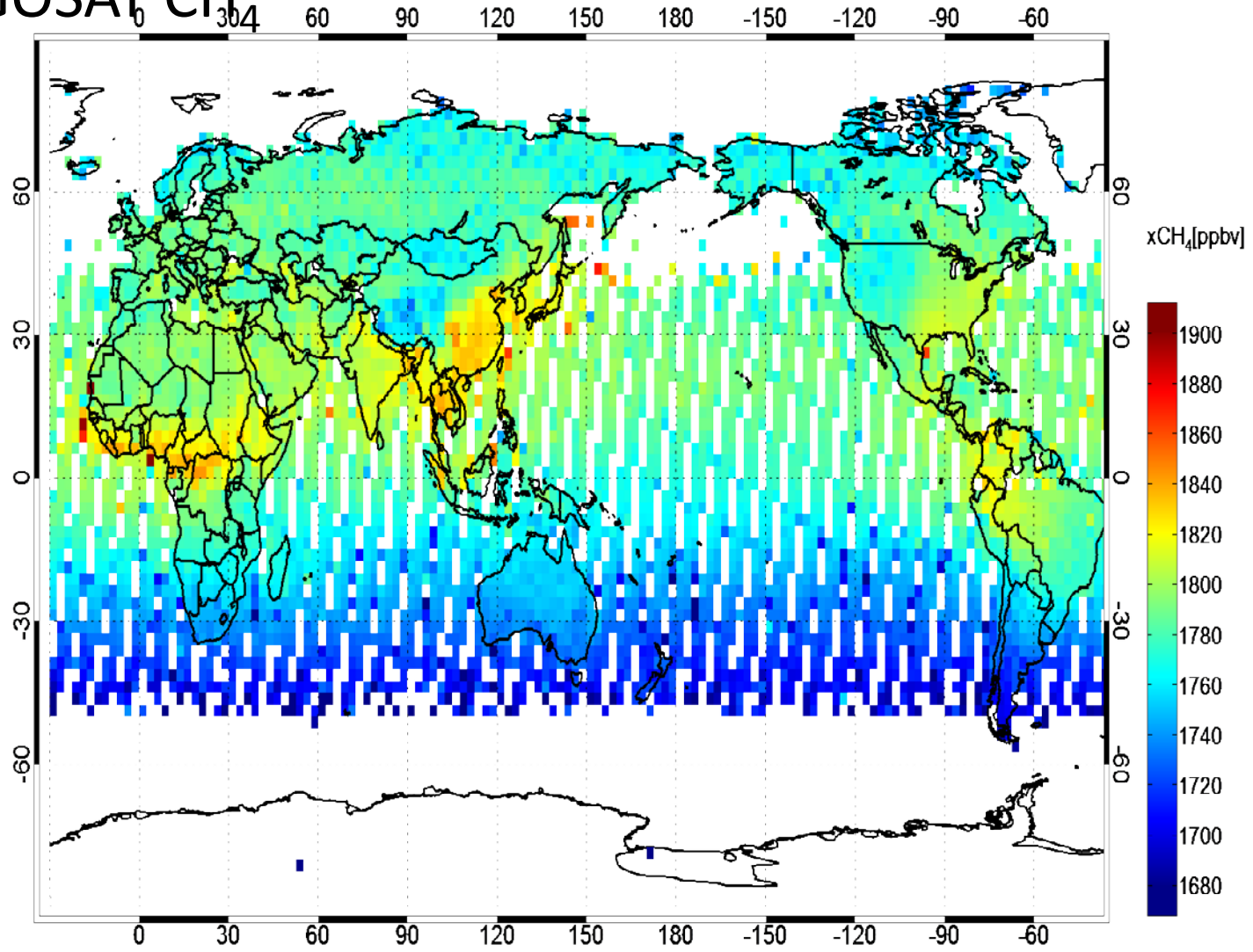
FIRST CH_4 global map (SCIAMACHY/ENVISAT)



Frankenberg et al., (2005, 2006)

Figure 5. Two-year average of methane VMR as retrieved by SCIAMACHY with less strict cloud filter (effective cloud top height less than 2.5 km) and gridded on 1° longitude times 1° latitude.

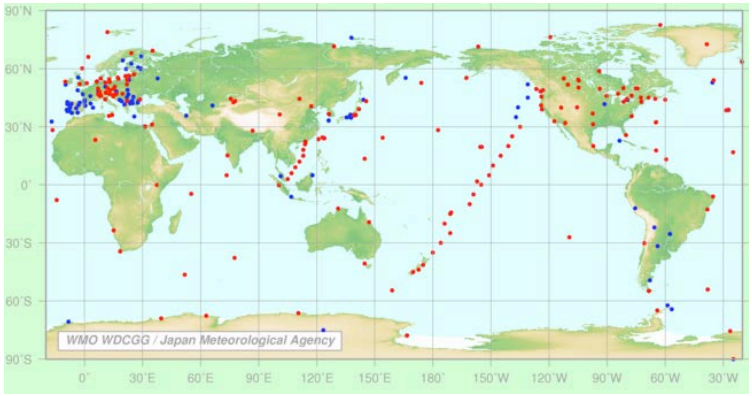
GOSAT CH_4



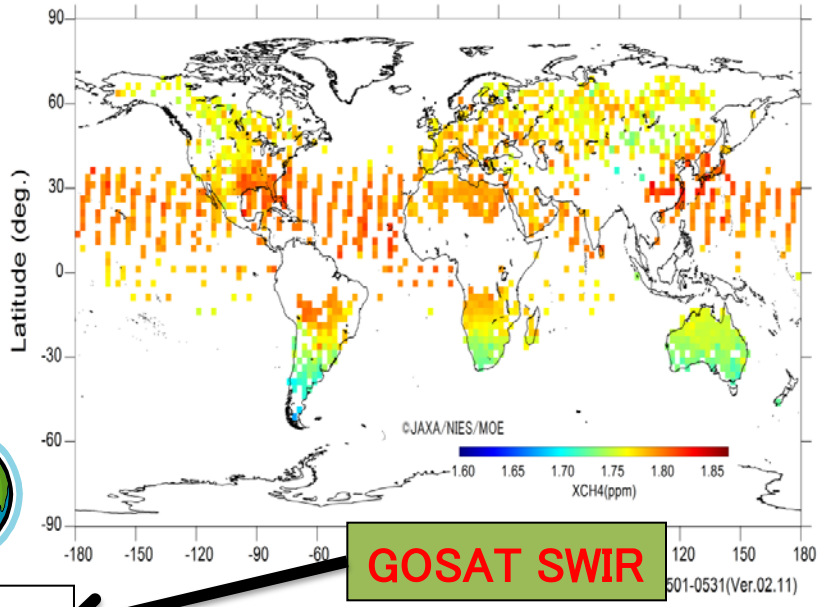
GOSATTFTS_RA_XCH4_allterm_grid25_200904_201405

Five-year average of global CH4 concentration : April 2009 – May 2014

GOSAT contributed to derive CH_4 global emission fluxes by using an inverse model



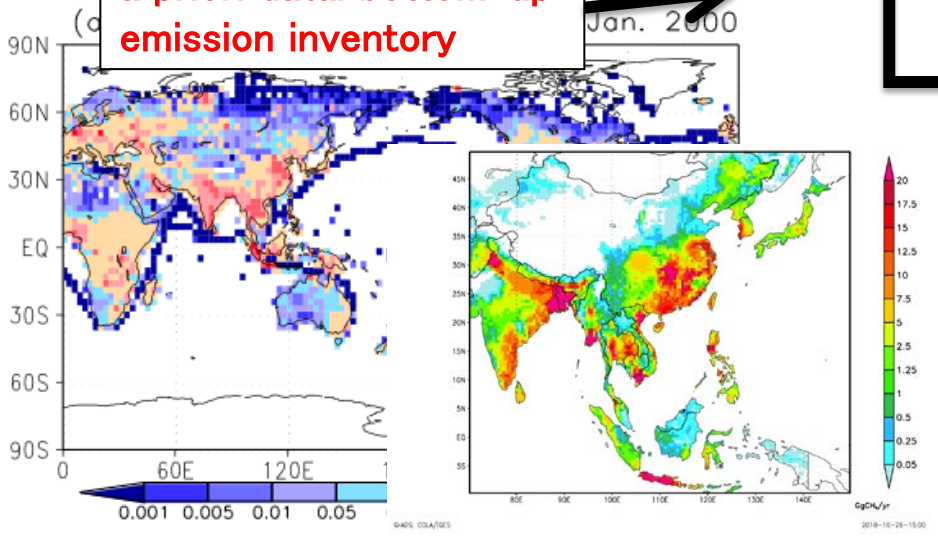
Global network measurements



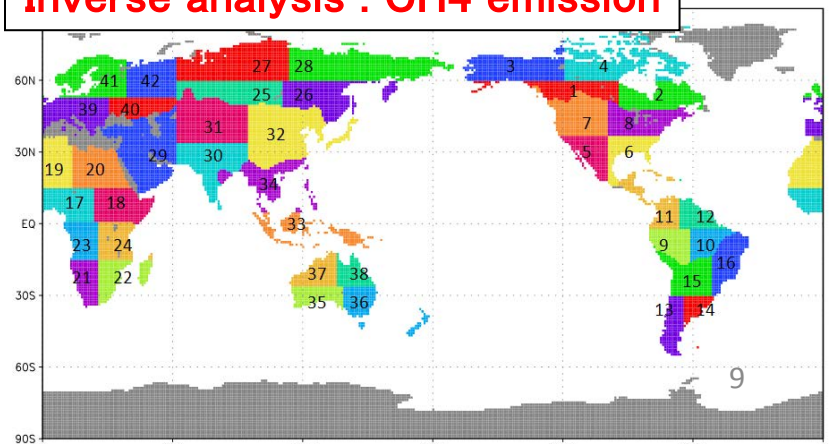
GOSAT SWIR

Transport model
Inverse model

a priori data: bottom-up emission inventory



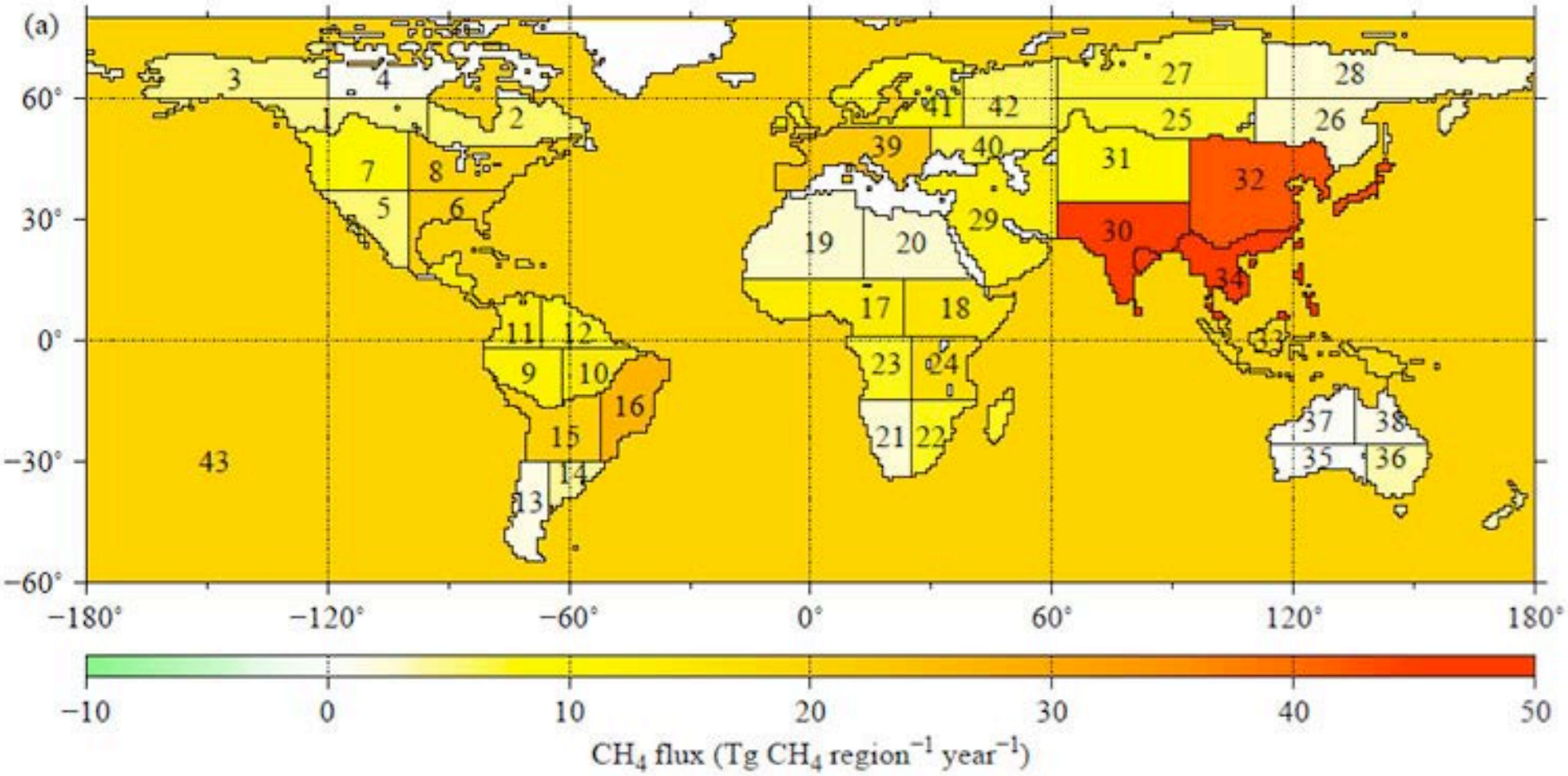
Inverse analysis : CH4 emission



Inverse analysis by NIES model with the GOSAT NIES product

from press release by NIES, March, 2014

Monsoon Asia is a big source of CH4



H.-S. Kim and S. Maksyutov (NIES)

Inverse analysis by NIES model with the GOSAT NIES product

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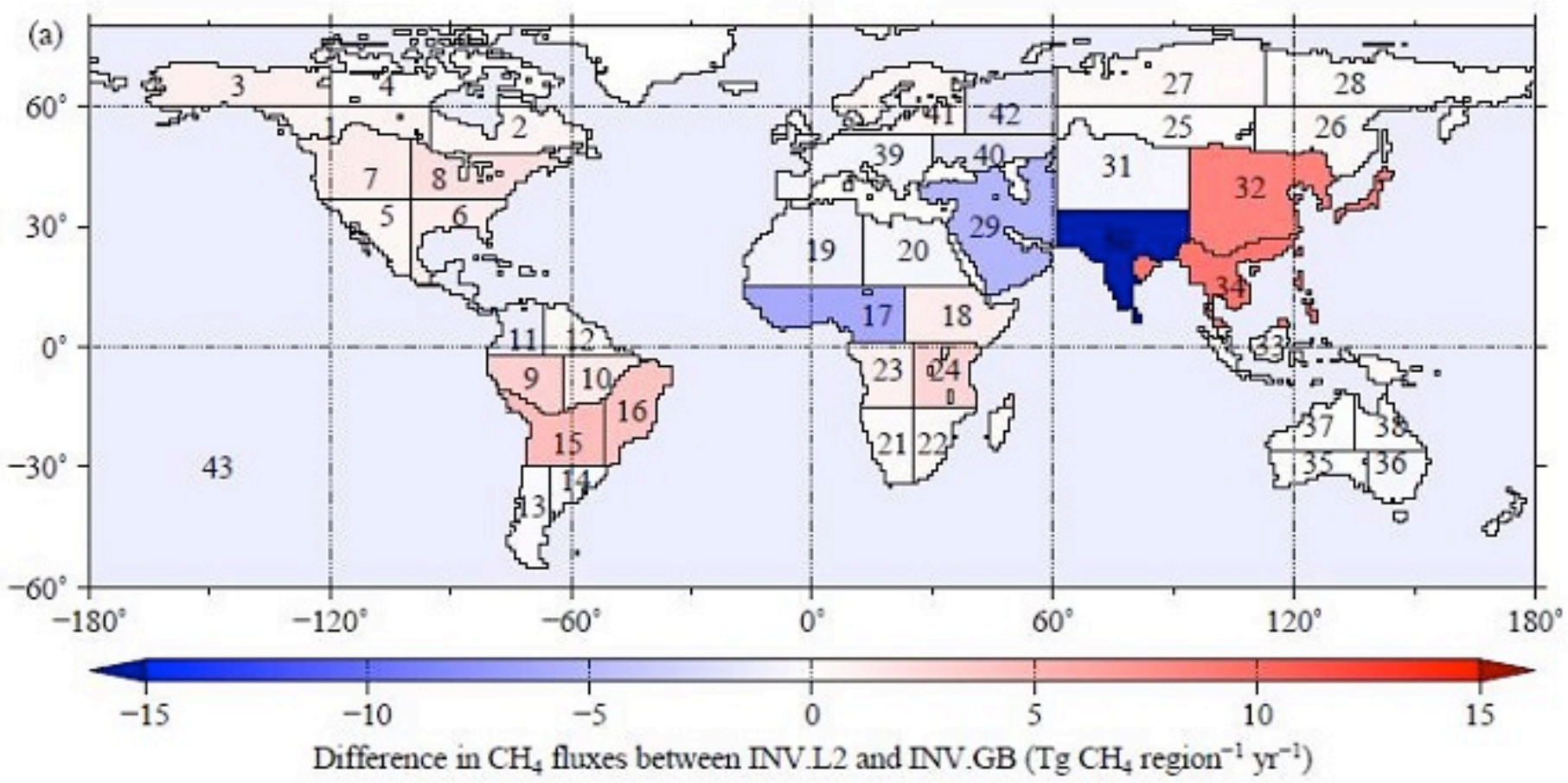
Difference between INV L2 and INV.GB
Is large: negative in India, positive in China



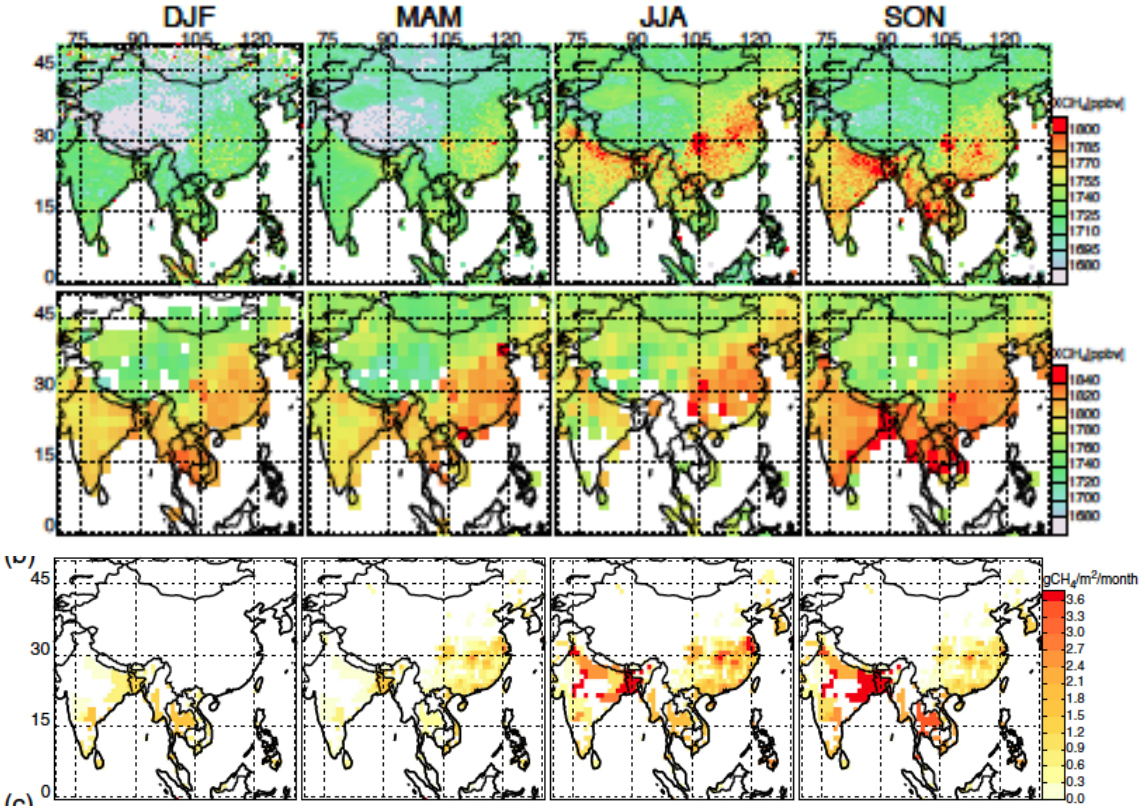
H.-S. Kim and S. Maksyutov (NIES)

- The geographical distribution of high CH4 values obtained from SCIAMACHY corresponds to strong emissions from regions where rice is cultivated, as indicated in the inventory maps.

SCIAMACHY
2003-2009

GOSAT NIES V2

GISS rice emission



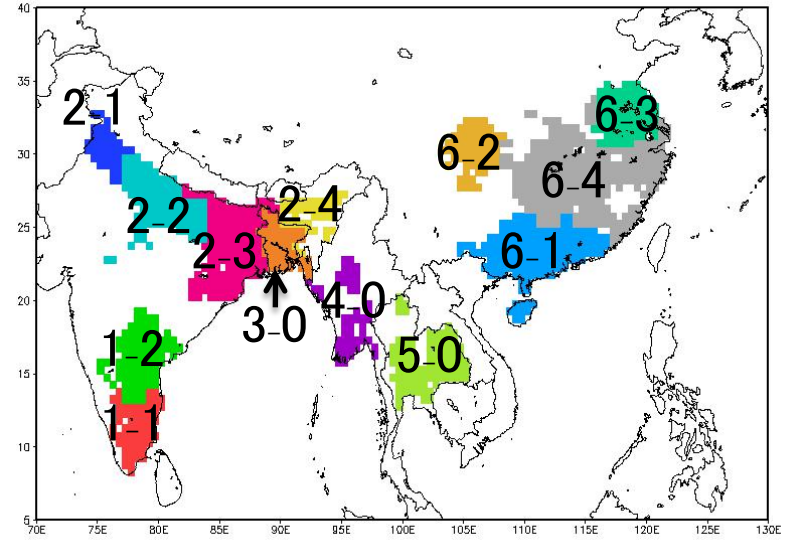
Hayashida et al., Remote Sensing of Environment (2013)

Typical rice paddies *Hayashida et al., RSE,2013*

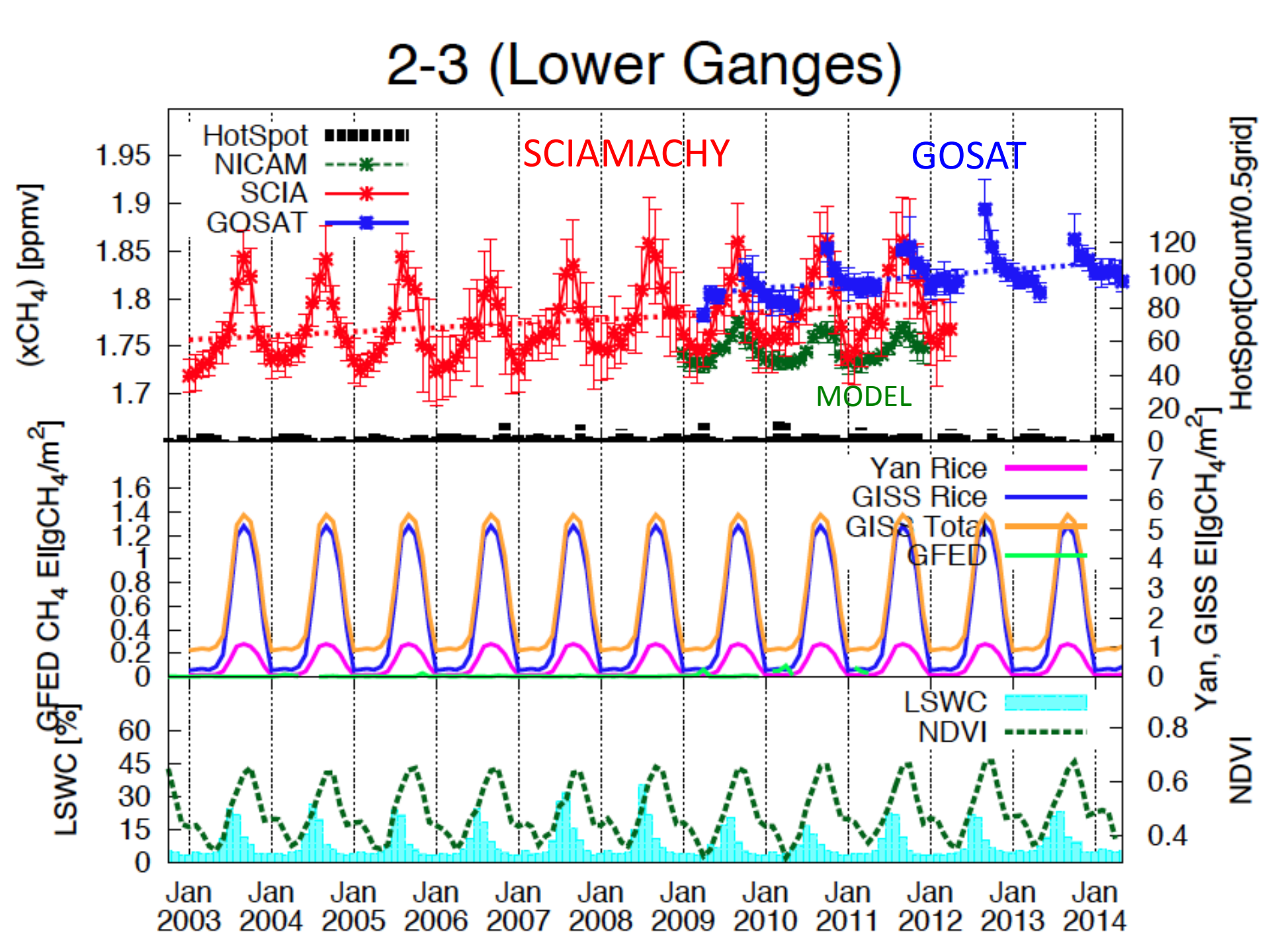
Selected: where the CH_4 emission values from rice fields are estimated to be higher than1.5gCH_4/m^2 .

Divided into sub-regions to distinguish different seasonality of emissions.

13 regions to be investigated



Region name	Area code	Sub areas
India (south)	Area 1	1-1, 1-2
India (north)	Area 2	2-1, 2-2, 2-3, 2-4
Bangladesh	Area 3	3
Myanmar	Area 4	4
Thailand	Area 5	5
China	Area 6	6-1, 6-2, 6-3, 6-4


2-3 (Lower Ganges)
HotSpot
NICAM
SCIA
GOSAT
SCIAMACHY
GOSAT
MODEL
(xCH4) [ppmv]
HotSpot[Count/0.5grid]
Yan Rice
GISS Rice
GISS Total
GFED
GFED CH4 EI[gCH4/m2]
Yan, GISS EI[gCH4/m2]
LSWC
NDVI
LSWC [%]
NDVI
Jan 2003
Jan 2004
Jan 2005
Jan 2006
Jan 2007
Jan 2008
Jan 2009
Jan 2010
Jan 2011
Jan 2012
Jan 2013
Jan 2014

GOSAT contribution to global estimate of CH_4 emission

- GOSAT contributed to estimate global CH_4 emission fluxes by applying an inverse model.
- GOSAT can detect regional characteristics of seasonality over rice paddies.

However, still a big uncertainty in CH_4 emission estimate is left.
e.g. Discrepancy between bottom-up and Inverse analysis is still unresolved

insufficiency of GOSAT :
*SWIR: Column average measurements
*Sparse measurements: IFOV of “10 km in diameter” does not mean spatial resolution of 10 km.

Strategy to overcome : GOSAT insufficiency -1

TIR (GOSAT)
ACE-FTS

Subtract information of CH4 in the lower atmosphere

Profile?

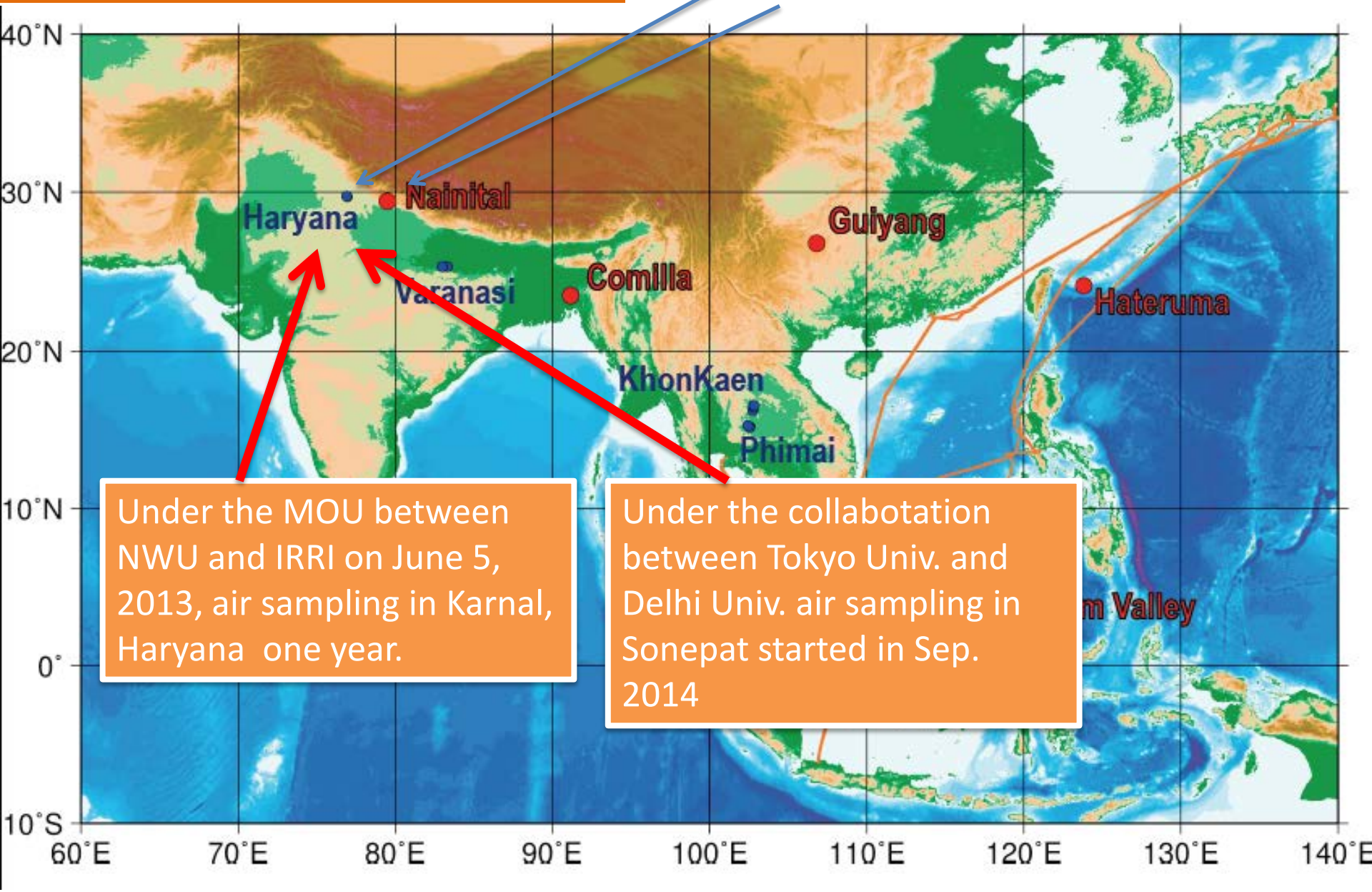
SWIR

column methane

SWIR measurements
Involve information in the lower atmosphere

Surface measurements
(e.g. air sampling)

Air sampling in North India



Courtesy of NIES group

Sonepat, Haryana (29.0N, 77.2E), Sep. 2014 – supported by Delhi Univ. and Tokyo Univ.

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insufficiency of GOSAT :
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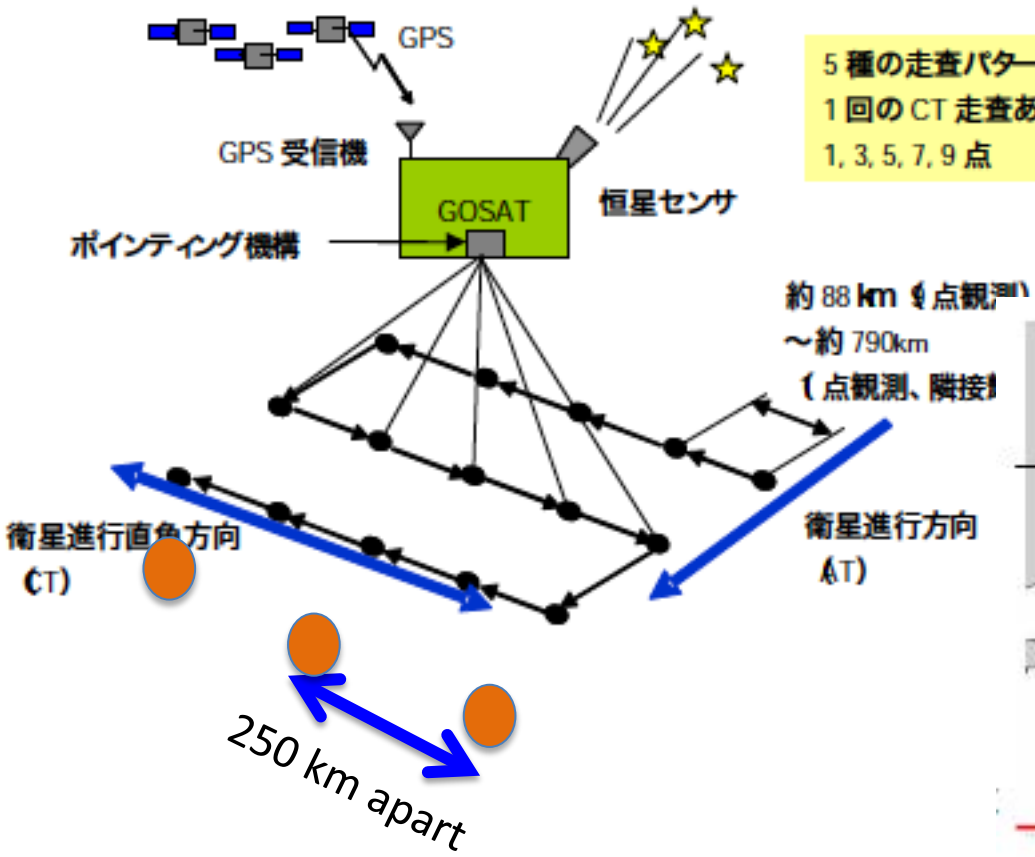
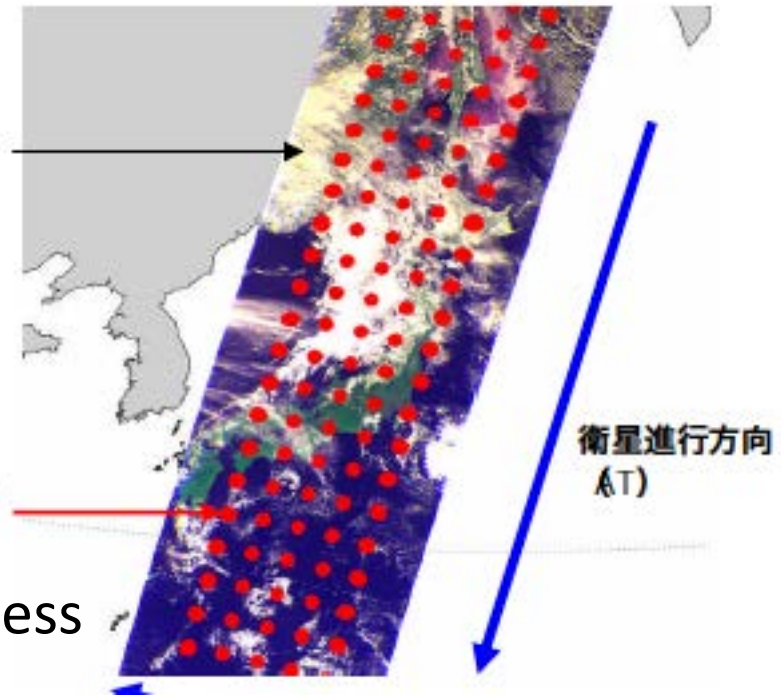
GOSAT insufficiency -2

3 points mode with 3-day recurrent orbit

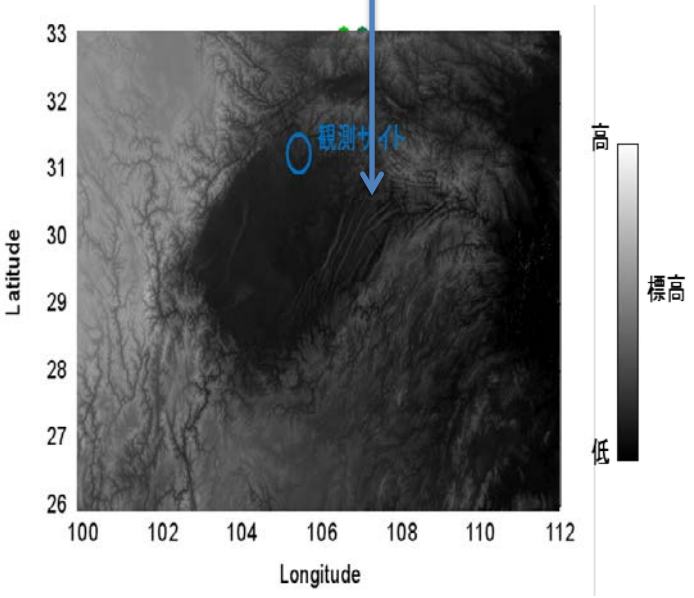




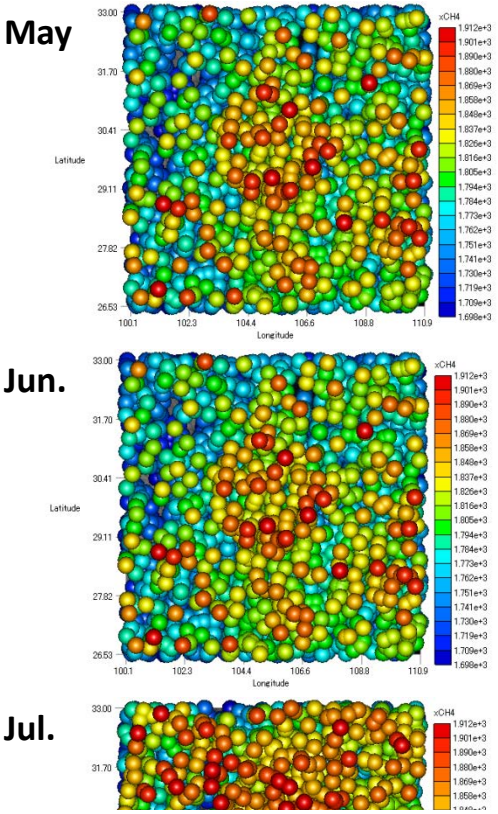
After cloud screening, numbers are much less

Example in Sichuan basin

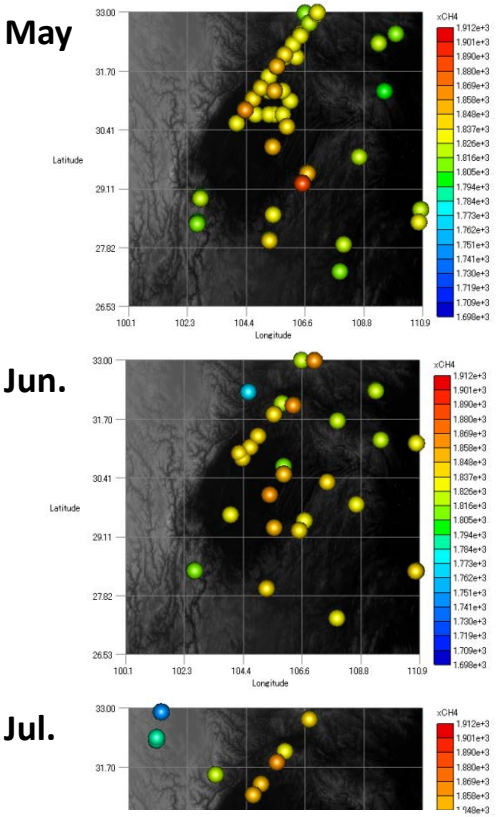
Mountain area



▽ SCIAMACHY xCH_4



▽ GOSAT xCH_4



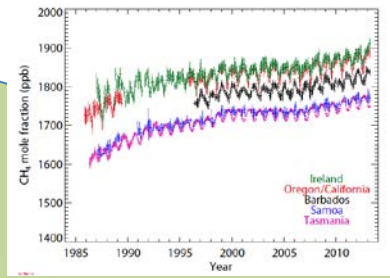
GOSAT-2 will be operated with 5 or more pointing mode

The orbit of GOSAT-2 : 6-day recurrent orbit.

More measurement points!

Next Step : Monitoring System toward Low Carbon Society

Chiba Univ.



Continuous Measurements

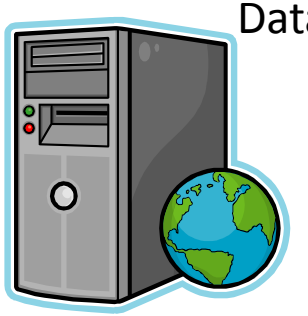
NIES

Flask air sampling

Global scale

Regional scale

Data Input



Transport model
Inverse model (JAMSTEC)

Flux estimate in Regional Scale

Mitigation Potential Map

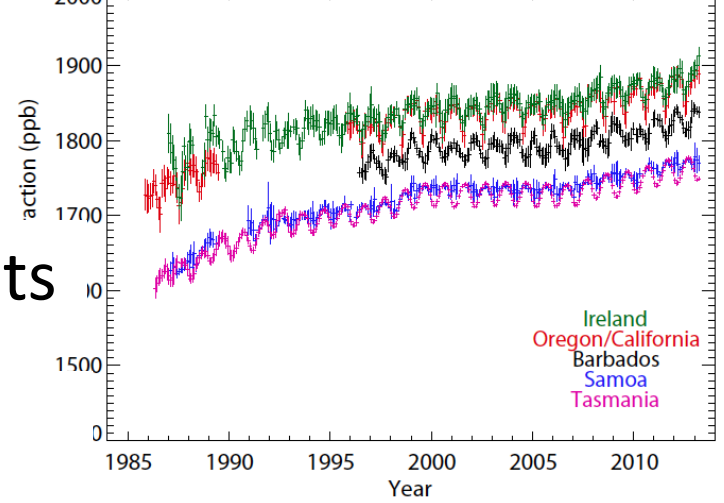
with NIAES

Mitigation Scenarios

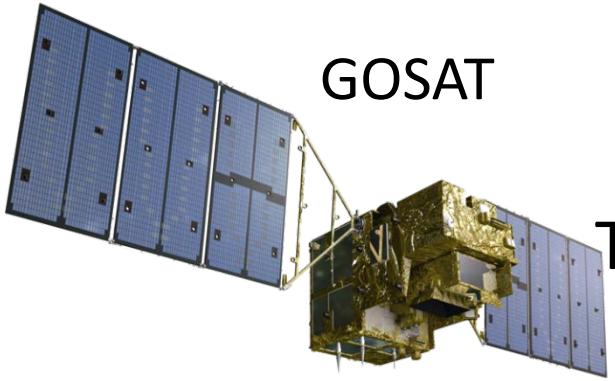
evaluation of mitigation options

Simulation of CH4 distribution

Continuous measurements

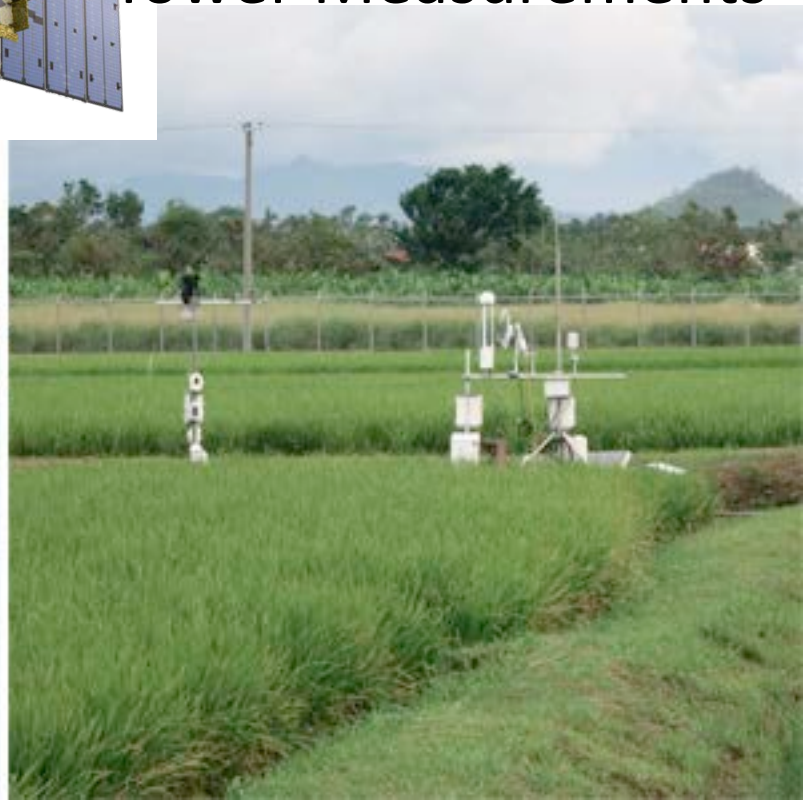


Flask air sampling

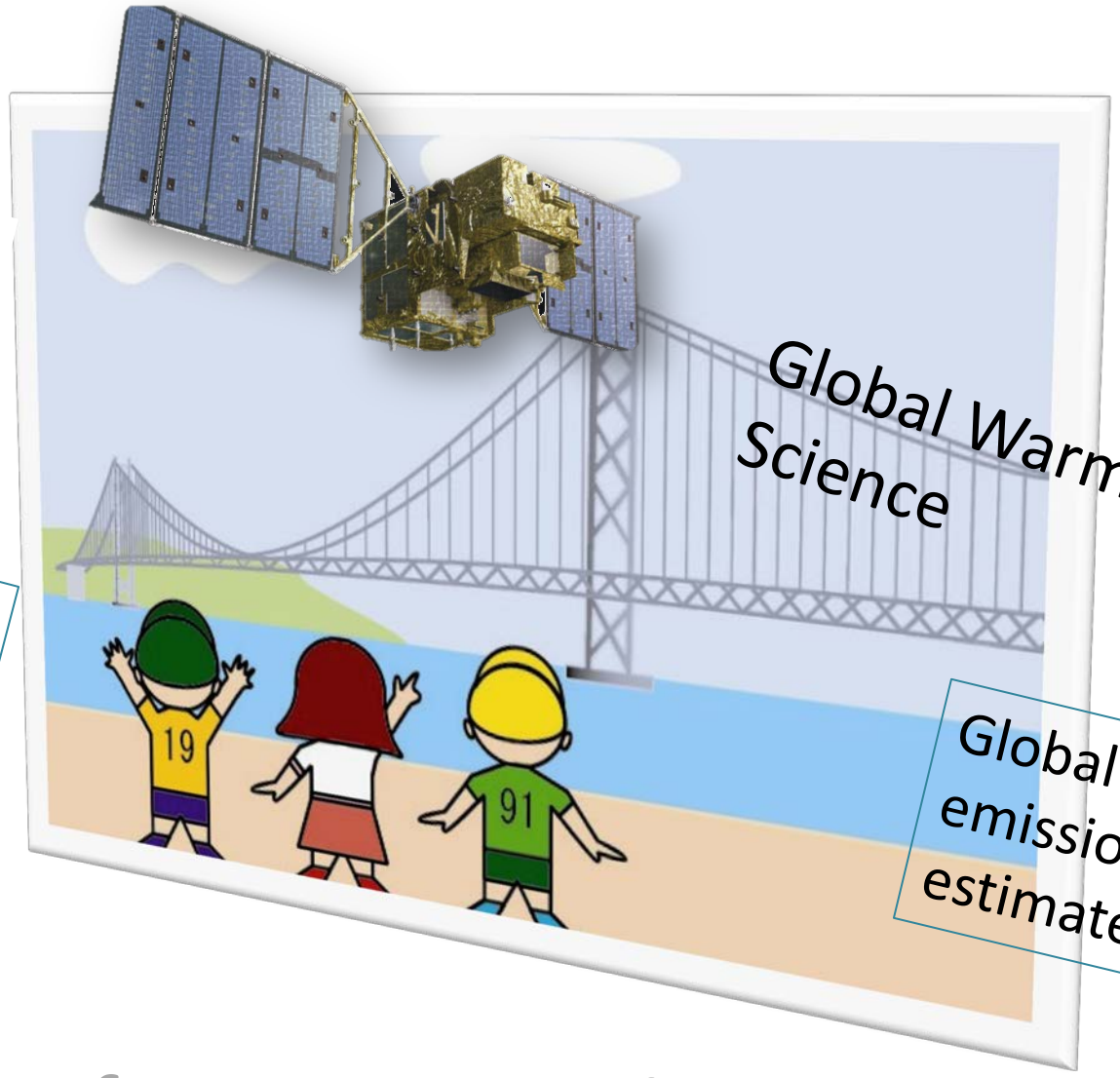


GOSAT

Tower Measurements

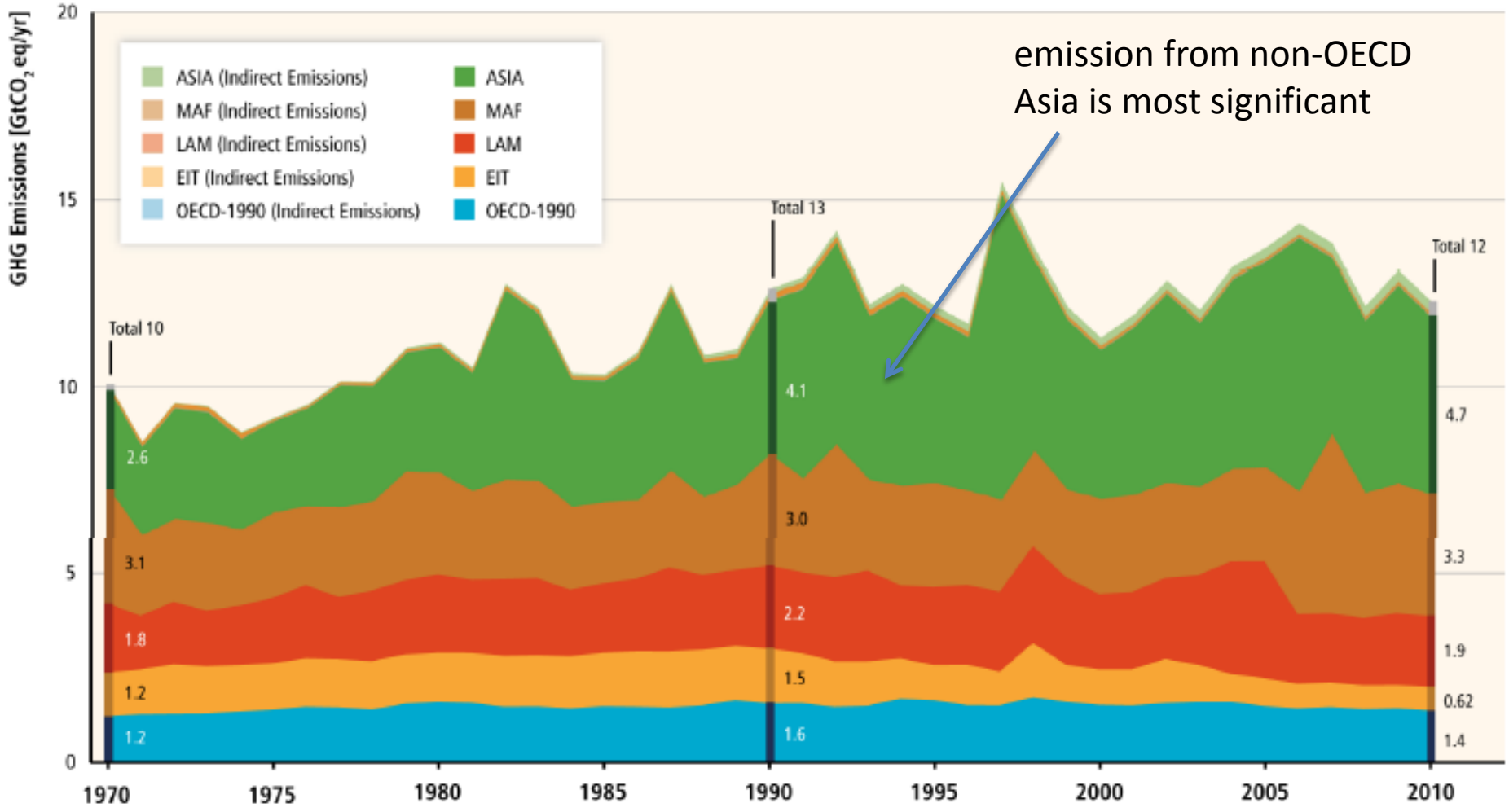


Actions toward Low Carbon Society



Thank you for your attention

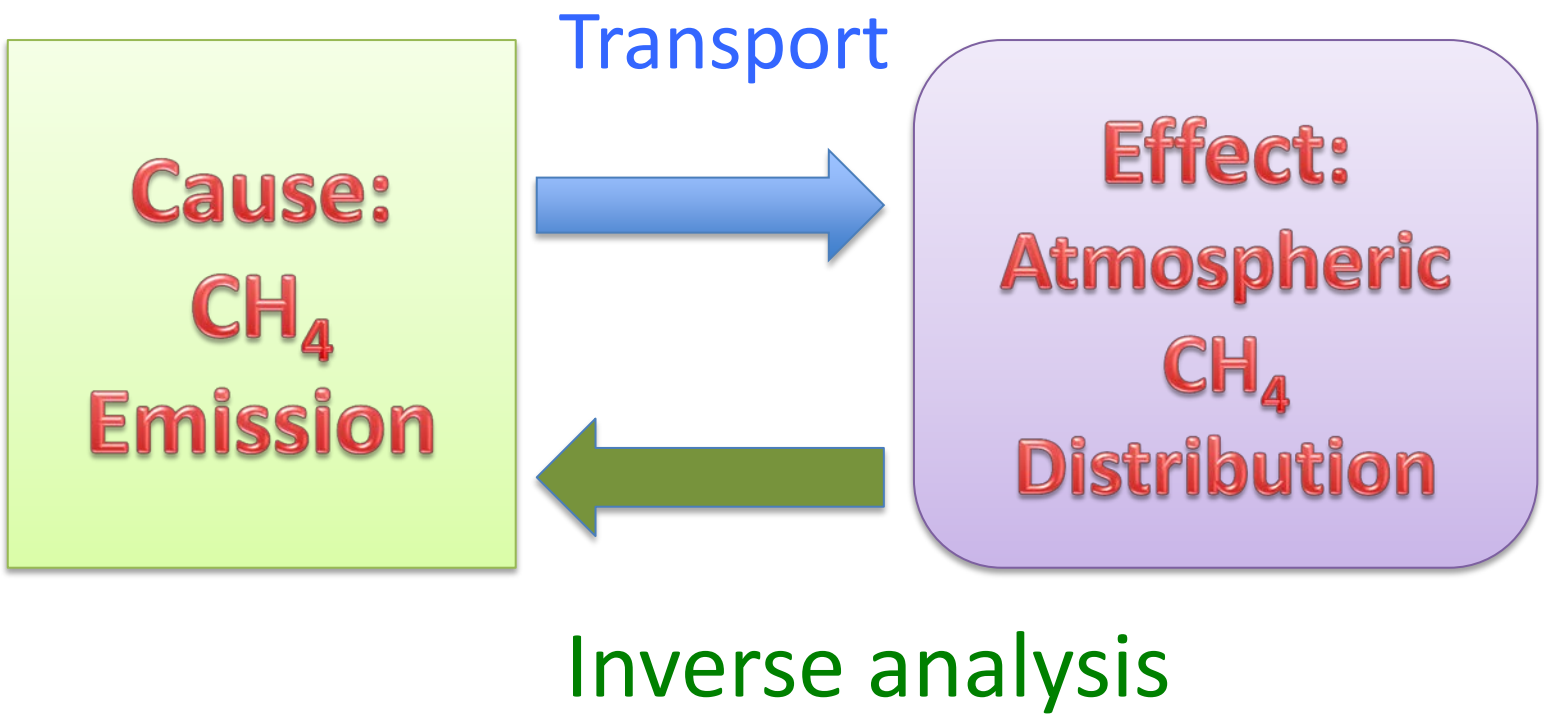
Methane Emissions from AFOLU for each RC5 region



Increasing population in Asia

Rice is primary food for Asian peoople

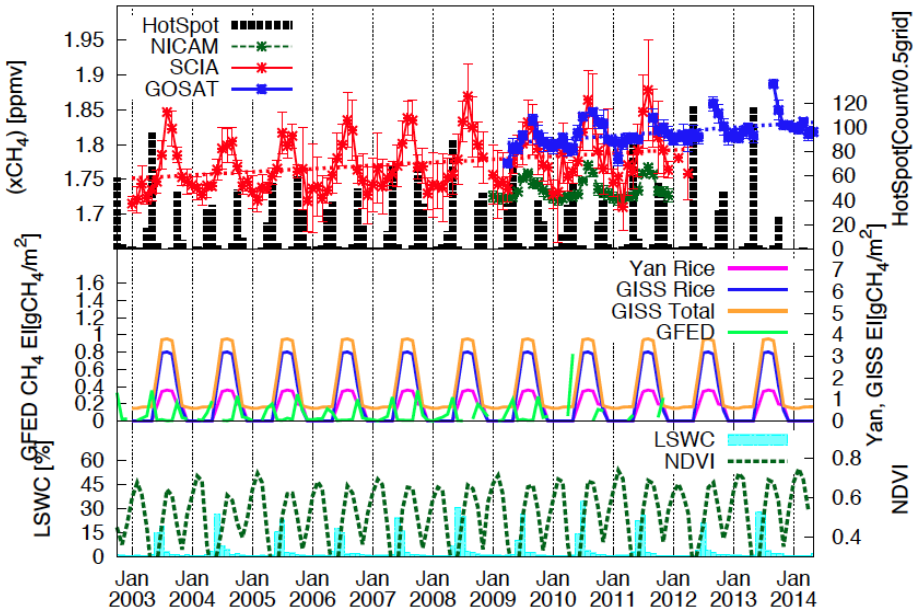
What is “inverse analysis”



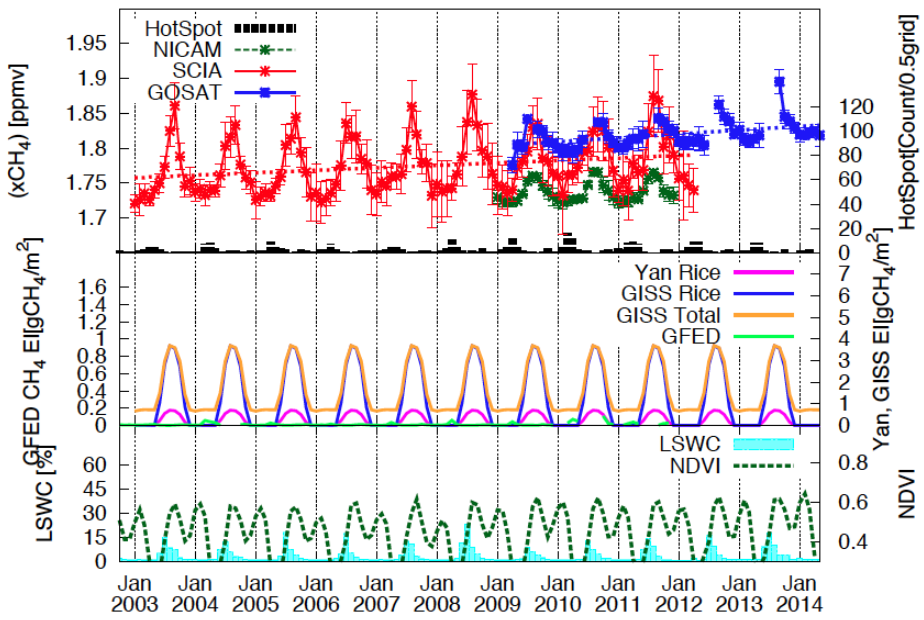
Bottom-up

Summing up the emissions from various categories based on statistics

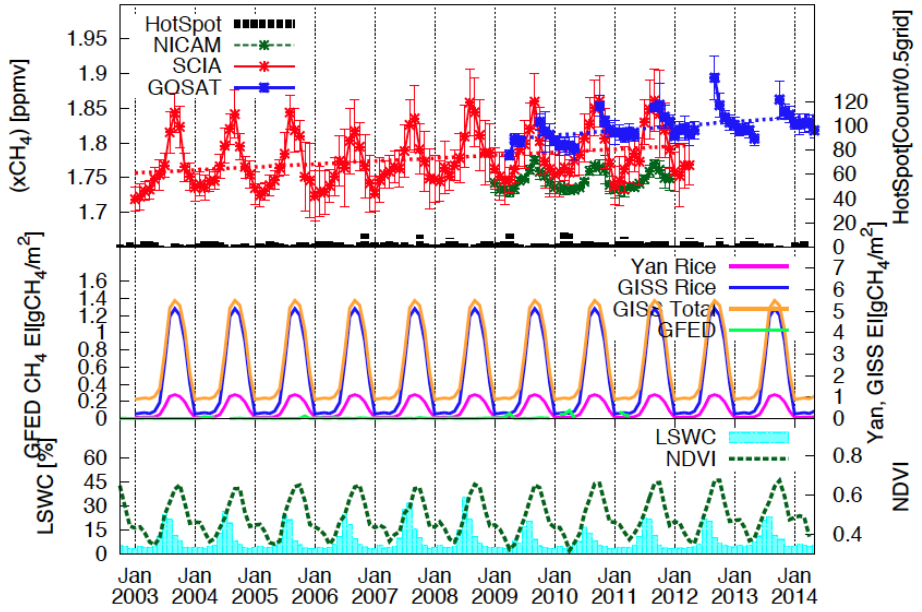
2-1 (Upper Ganges)



2-2 (Mid Ganges)



2-3 (Lower Ganges)



2-4 (Brahmaputra Basin)