Comparison of methane concentrations observed from space with model simulation over Monsoon Asia

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Introduction

The concentration of atmospheric methane (CH_4) has more than doubled since pre-industrial times, and its radiative forcing is estimated to be the second largest after carbon dioxide (CO_2).However, despite the importance of atmospheric CH_4 in global warming, the significance of individual sources of CH_4 remains highly uncertain. Monsoon Asia accommodates about 90% of the world's rice fields, and they have a big influence on the global environment. In this study, we analyze model simulation using NICAM-TM-CH4 and satellite data (SCIAMACHY and TANSO-FTS) to understand CH_4 behaviour over Monsoon Asia.

Datasets

❖ **CH_4 concentration**

Sensor	Satellite	Reference
SCIAMACHY	ENVISAT	Frankenberg et al.(2011)
Sensor	**Satellite**	**Version**
TANSO-FTS	GOSAT	NIES*1 (v.2.20 and v.2.21)

❖ **Satellite-derived indices**

Database	Satellite	Grid archived	Reference
LSWC*2	Terra / Aqua	0.5˚×0.5˚	Takeuchi and Gonzalez.(2009)
NDVI*3	Terra	1.0°×1.0°	Huete et al.(2002)

❖ **Emission inventory**

Database	Emission category	Grid archived	Reference
Yan2009	Rice fields	0.5˚×0.5˚	Yan et al.(2009)
GISS	All categories	1.0°×1.0°	Matthews et al.(1991)

*1: National Institute for Environmental Studies
*2: Land-surface water coverage
*3: Normalized difference vegetation index

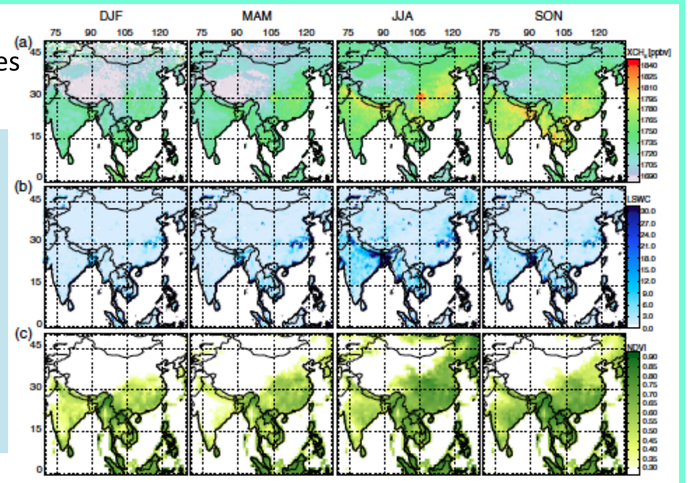
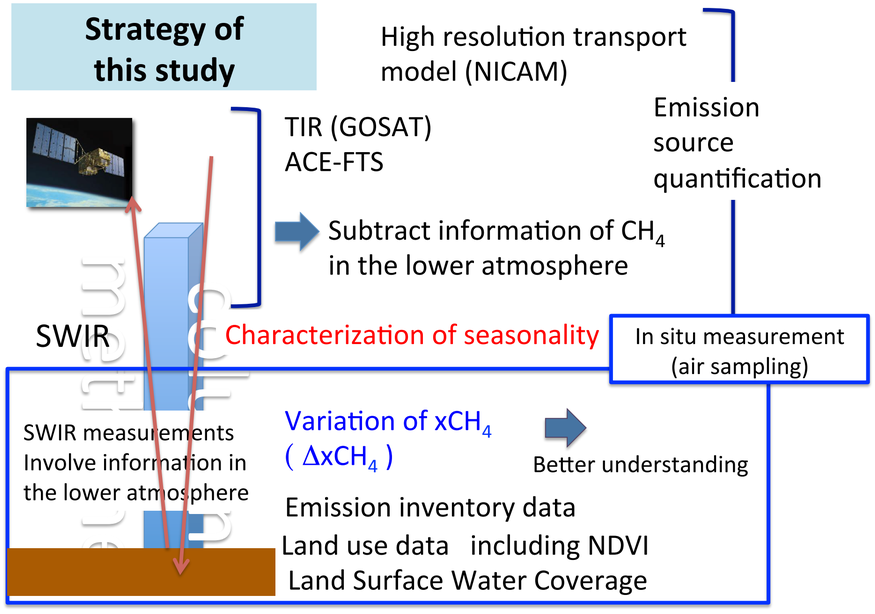


Fig. 1: Maps of 3-month averaged values of (a)SCIAMACHY, (b)LSWC, (c)NDVI.

(a)SCIAMACHY, (b)LSWC, (c)NDVI
All data have been averaged for 6 years from 2003 through December 2008.The columns correspond to DJF, MAM,JJA, and SON, respectively.

DJF: from December to February
MAM: from March to May
JJA: from June to August
SON: from September to November

Strategy of this study



NICAM（Nonhydrostatic ICosahedral Atmospheric Model）- TM（Transport Model） Y. Niwa and R. Imasu

NICAM Model output

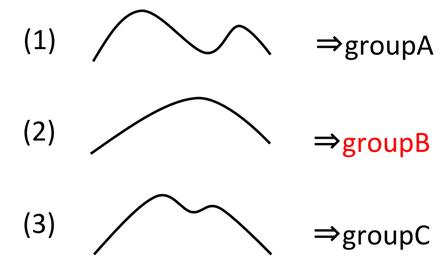
Scenarios of NICAM model run
(after Master thesis of Takamizawa, Tokyo Univ, 2012)

Scenario name	Anthro-pogenic	Wetland	Biomass Burning	Rice	others
CTL	EDGAR3.2	GISS	GISS	Yan2009	GISS (termite)/ oceanic exchange/ mud volcanic emissions

2.5 deg. x 2.5 deg, 40 layers, monthly average
Meteorological condition in 2007 (fixed)

Cluster analysis of the xCH_4 seasonality

In this study, we have observed the characteristics of seasonal variation in Asia by using the cluster analysis.



xCH_4 seasonal variation over typical rice paddies

[Hayashida et al., RSE,2013]

We selected some sampling regions where the CH_4 emission values from rice fields are estimated to be higher than1.5gCH_4/m^2.
Those areas were divided into sub-regions to distinguish different seasonality of emissions.

Fig.2: 13 regions to be investigated

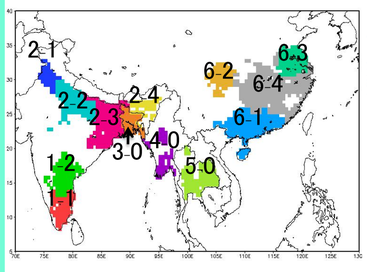
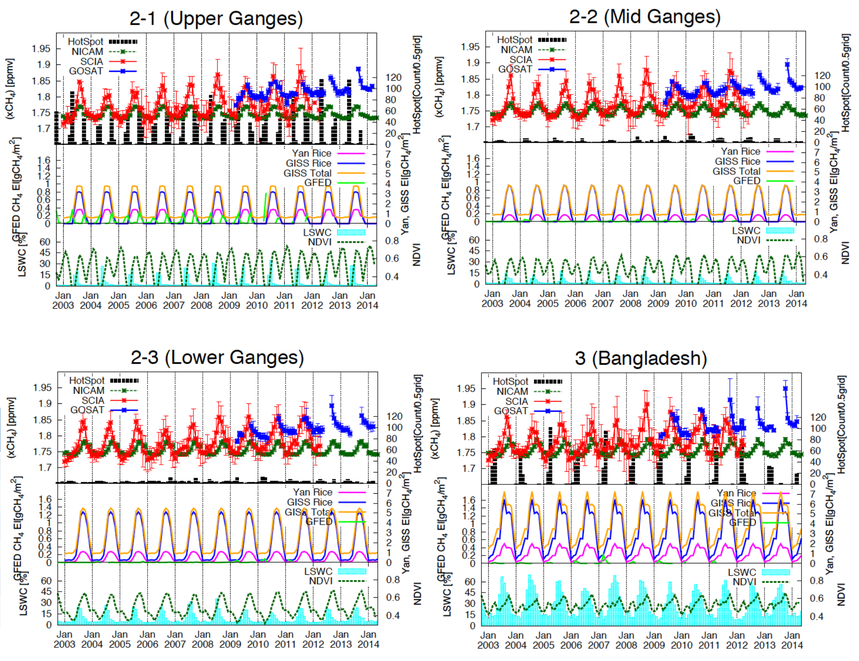


Fig. 3: Seasonal variation

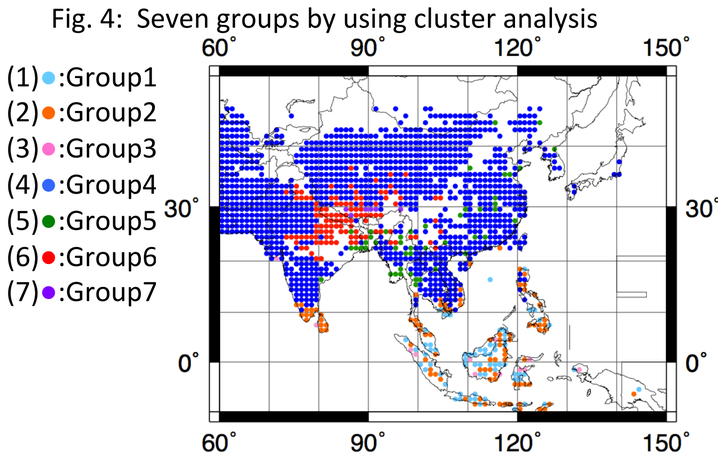


Summary of areas

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

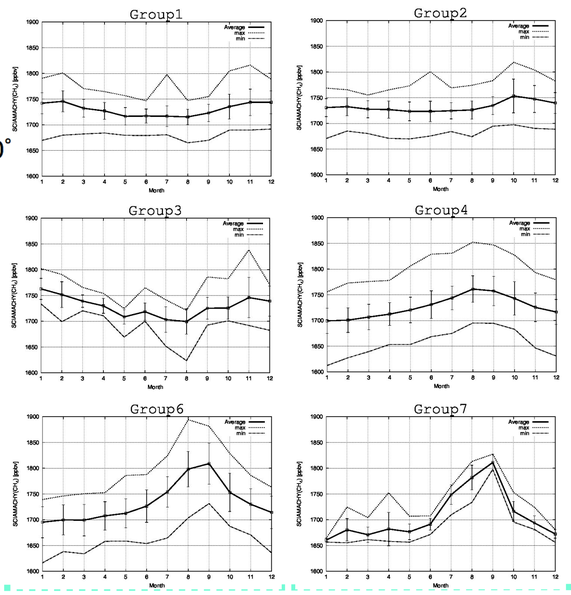
[Seven groups of CH_4 seasonal variation]

Fig. 4: Seven groups by using cluster analysis



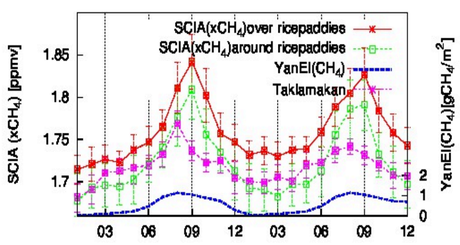
Top: maximum
Middle: average
Bottom: minimum
Error bar: the standard deviation
the vertical axis: concentration
the horizontal axis: month

Fig. 5: Seasonal variation of 7 groups



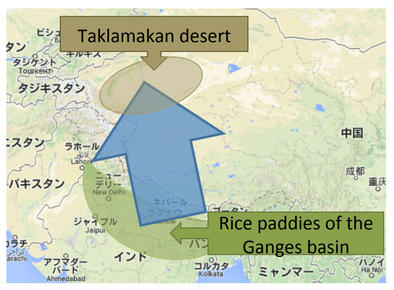
[Group6(include Area2-1,2-2,2-3,2-4)]

Fig. 6: Seasonal variation around 2.0 grid of rice cultivation



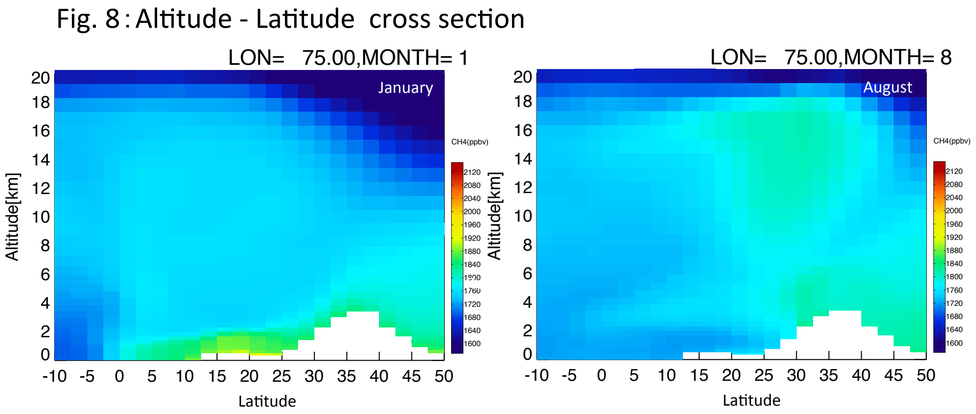
Blue: CH_4 from rice paddies
Red: CH_4 concentration over rice paddies
Green: CH_4 concentration around rice paddies
Pink: CH_4 concentration over Taklamakan desert

Fig. 7: Map around the Ganges basin



NICAM Simulation Upper Ganges (Area2-1)

Fig. 8: Altitude - Latitude cross section



Upwelling motion must have affected on enhancement of xCH_4 in August in the Ganges Basin.
GOSAT-TIR and ACE-FTS data are now under investigation

Summary

We showed the characteristics of CH_4 distribution in Monsoon Asia. The seasonality of xCH_4 observed by SCIAMACHY is characterized by high values particularly during the wet seasons. High correlation coefficients (r) between xCH_4 and rice emission estimate is indicated, which suggests the strong connection between the atmospheric CH_4 concentration and the CH_4 emissions from rice cultivation for most of the areas in Monsoon Asia. The results obtained in this study demonstrate the potential of satellite observation at short-wavelength infrared (SWIR). However, it can provide information only for the column-averaged concentration, and vertical distribution is not detectable. Model simulation suggests CH_4 plumes in the upper troposphere over north India. Couples analysis of satellite and model simulations are now under study.

[Acknowledgments]
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[References]
Hayashida et al., 2013, Remote Sensing of Environment 139,246-256 .
Frankenberg, C., et al., 2011, Journal of Geophysical Research, 116, D04302.
Yan,X., et al., 2009, Global Biogeochem Cycles, 23, GB2002.

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