Comparison of GOSAT CH$_4$ measurements with in-situ measurements and model simulations —Application of GOSAT CH$_4$ data to Agricultural CH$_4$ emission in Asia—

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*Atmospheric Methane and Agriculture in South Asia


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Introduction

• Despite the importance of atmospheric CH$_4$ in global warming, the significance of individual sources of CH$_4$ remains highly uncertain.
• Asia is one of the most significant areas of CH$_4$ emissions.

Question
Where is the source of CH$_4$ in Asia, and how much? What are the effects that control methane emission?
Seasonal variation of CH$_4$ over rice paddies

<table>
<thead>
<tr>
<th>Region name</th>
<th>Area code</th>
<th>Sub areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>India (south)</td>
<td>Area 1</td>
<td>1-1, 1-2</td>
</tr>
<tr>
<td>India (north)</td>
<td>Area 2</td>
<td>2-1, 2-2, 2-3, 2-4</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>Area 3</td>
<td>3</td>
</tr>
<tr>
<td>Myanmar</td>
<td>Area 4</td>
<td>4</td>
</tr>
<tr>
<td>Thailand</td>
<td>Area 5</td>
<td>5</td>
</tr>
<tr>
<td>China</td>
<td>Area 6</td>
<td>6-1, 6-2, 6-3, 6-4</td>
</tr>
</tbody>
</table>

updated from Hayashida et al., RSE, 2013

✓ Regular seasonal variation of XCH$_4$ over rice paddy regions has been continuing.
✓ The long-term increasing trend is observed clearly.
Application of GOSAT CH$_4$ measurements to Agriculture

AMASA (Atmospheric methane from agriculture in South Asia) a project sponsored by the Environment Research and Technology Development Fund (ERTDF a-1502) :
April 2015-March 2018 Leader: Sachiko Hayashida

**Goal 1:** Improvement of Methane Emission Estimate from South Asia using GOSAT

**Goal 2:** Development of an Emission Mitigation Proposal

Mitigation scenarios from rice fields by proper water management and/or fertilizer management

Evaluation: realizable? detectable?
Monitoring System toward Improvement of Emission Estimate

Data Input

GOSAT

NIES

Global scale

Continuous Measurements

Flask air sampling

Flux estimate in Regional Scale

ACTM Inverse analysis (JAMSTEC)

Simulation of CH4 distribution

Nagoya Univ. (Y. Matsumi) & Tokyo Univ. (R. Imasu)
Tokyo Gakugei Univ.

Goal 2

Mitigation Potential Map

NIAES, Chiba Univ.

Mitigation Scenarios

at Tamil Nadu

Regional scale
Collaboration in India and Bangladesh

Flask sampling and Laser measurements at Sonepat

Mitigation experiment at Tamil Nadu Rice Research Institute (TRRI)

Hi!
GOSAT/SWIR + GOSAT/TIR + in-situ measurement vs. ACTM over Indo-Gangetic plain

SWIR measurements
Involve information in the lower atmosphere

Get information of CH₄ in the lower atmosphere

In situ measurement (Flask sampling)
GOSAT XCH$_4$ NIES V.2.x: Monthly average

Karnal and Sonepat  Comilla

GOSATTFTS_RA_XCH4_monthly_grid25_200904
GOSAT XCH\textsubscript{4} NIES V.2.x: Monthly average

Oct. 2010
White = No data

Oct. Average 2009-2013

July and August: very limited data

Oct. 2011


Oct. 2013
Flask sampling network of NIES

Karnal: 2013.8-2014.8
Nainital 2006~
Comilla 2012~
Sonepat 2014. 9~

Courtesy of Yukio Terao
Air sampling vs. ACTM (P. Patra/JAMSTEC)

CH$_4$ in the sampled air

Karnal: (one year) Dec-Feb: enhanced CH$_4$

Sonepat: (1.5 years) Dec-Feb.: enhanced CH$_4$

Flask

ACTM T106
Air sampling vs. ACTM (JAMSTEC)

CH$_4$ in the sampled air

ACTM T42
Comparison of ACTM (T42:~2.8°), GOSAT, Hotspots, Emission Inventory, NDVI, and LSWC

Monthly basis

Surface CH4
ACTM(T42)

GOSAT XCH4

Hotspots

Emission Inventory

Agricultural Burning
after Wheat and Rice

LSWC

NDVI

Rice

Wheat
MODIS Hotspots in north India
Both CH$_4$ and CO enhancement in late autumn to winter (Oct.-Feb.) over Karnal and Sonepat.

- ACTM T106 reproduced absolute values fairly well.
- Seasonal variation of ACTM T42 does not show winter maximum (Sep/Oct maximum).
- Over Comilla, Patra et al. (2016) described that the CH$_4$ build up at the surface during the winter because the loss of CH$_4$ is at its seasonal low, and transport mechanism.
- Another agricultural burning after rice is effective? But the most active hot spots are found in Oct. and Nov.
Summary

• Long-term record of GOSAT/SWIR XCH$_4$ over Asia
  – Regular seasonal variation is continuing.
  – Growth rate of GOSAT XCH$_4$ is comparable with SCIAMACHY
• GOSAT XCH$_4$ distribution
  – High in summer monsoon season over Indo-Gangetic plain
• Flask sampling in Karnal/Sonepat
  – Winter maximum for both CH$_4$ and CO
• Comparison with ACTM/JAMSTEC over Karnal/Sonepat
  – ACTM(T106) reproduces flask sampling fairly well, when looking at day-by-day.
  – ACTM(T42) shows Sep/Oct maximum, corresponding to rice emission?
  – Patra et al., JMSJ, 2016: (over Comilla) the CH$_4$ build up at the surface during the winter => the situation is different over Karnal/Sonepat?
  – Effect of BB in October/November?
• Representativeness of measurements
  – Continuous measurement by LaserMethane instrument (by Matsumi) is important to follow the data gap of flask sampling (once a week)!
Biomass burning: Between rice and wheat cultivation periods

Agricultural burning after wheat in May, after rice in Oct/Nov.