Rapid and Accate Measurements of Methane Emissions from Rice Paddies under the APN CAPaBLE GHG Project

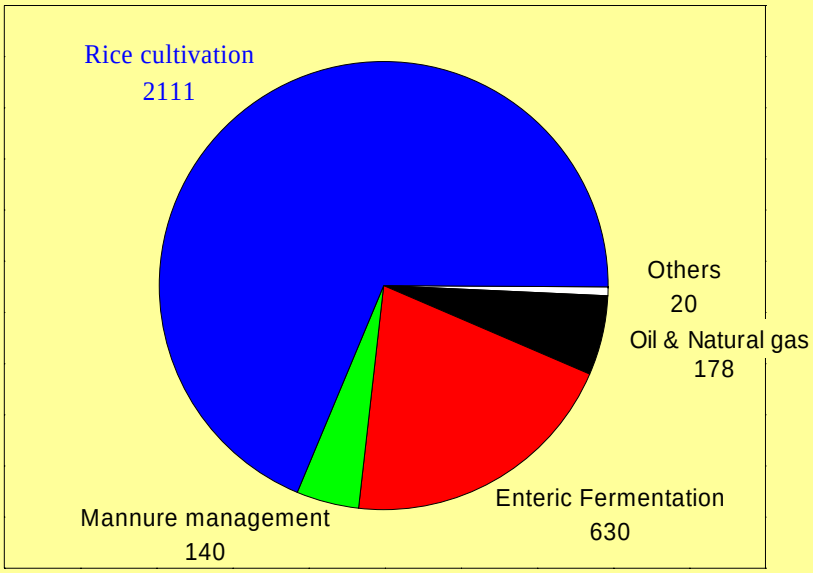
Amnat Chidthaisong

Joint Graduate School of Energy & Environment,
King Mongkut's University of Technology
Thonburi, Bangkok, Thailand

Thailand Greenhouse Gas Inventory 1994

GHGs	Emission (Gg)	CO_2-equivalent (Gg)	%
CO_2	202,458	202,458	71
CH_4	3,171	66,598	23
N_2O	56	17,317	6

Methane Emission from Thailand (Gg, 1994)



Current Inventory

➔ **Emission Factors calculated from;**

-Derived using the average of the measurements conducted in four typical rice growing areas in Thailand (1.56 kg-CH_4 per ha per d) which were under continuous flooding (no fertilizer) in the wet season during 1992 to1994

-The average methane emission rate was converted according to different water regimes and organic matter amendment using IPCC correction factors.

Table 3.1 Measured Methane Emissions in kg CH_4/ha/day from Various Rice Cultivation Areas, with and without Soil Amendments

Province	Soil series	NF	CF	CF+OM	Average
Pathum Thani	Rangsit	0.45	0.73	1.11	0.763
Ratchaburi	Nakornpathom	1.13	2.32	5.93	3.127
Surin	Roi-et	3.77	5.41	6.33	5.170
Chiangmai	Hang Dong	0.89	1.76	1.31	1.320
Average		**1.56**	**2.56**	**3.67**	**2.595**

Notes: NF = no fertilizer application

CF = with chemical fertilizer amendment

CF + OM = with both chemical and organic fertilizer amendment

Source: Jermsawatdipong, *et al.* 1994.

Table 3.2 Methane Emission Factors for Different Water Ecosystem and Organic Amendment

Category	Sub-category		Scaling factors for rice ecosystem	Correction factors for organic amendment	Emission factors kg CH_4/ha/day
Major rice					
Upland	Rainfed	–	0	1	0
	Irrigated	Continuously flooded + OM	1	2	3.120
		Continuously flooded	1	1	1.560
Low land	Rainfed	Flood prone	0.8	2	1.248
		Flood prone + OM	0.8	1	2.496
		Drought prone	0.4	1	0.624
		Drought prone + OM	0.4	2	1.248
	Deep water	Water depth > 100 cm	0.6	1	0.936
Second rice	Irrigated	Continuously flooded + OM	1	2	3.120

Local EF IPCC EF

Category	Sub-category		Seasonal flux (g CH_4/sq m)	Cultivation area (ha)	CH_4 emission (Gg)	
Major rice						
Upland	Rainfed	-	0.00	34,048	0.00	0.00
Low land	Irrigated	Continuously flooded + OM	44.04	1,121,492	493.90	420
		Continuously flooded	18.72	1,121,492	209.94	210
	Rainfed	Flood prone + OM	14.98	1,100,926	164.87	165
		Flood prone	35.23	1,100,926	387.88	330
		Drought prone + OM	17.62	2,184,333	384.79	327
		Drought prone	7.49	2,184,333	163.56	164
	Deep water	Water depth > 100 cm	15.31	39,478	6.04	8
		Total		**8,887,026**	**1,811.00**	
Second rice	Irrigated	Continuously flooded	44.04	680,123	299.53	1623
		Total Emissions		**9,567,149**	**2,110.53**	225
						1,878

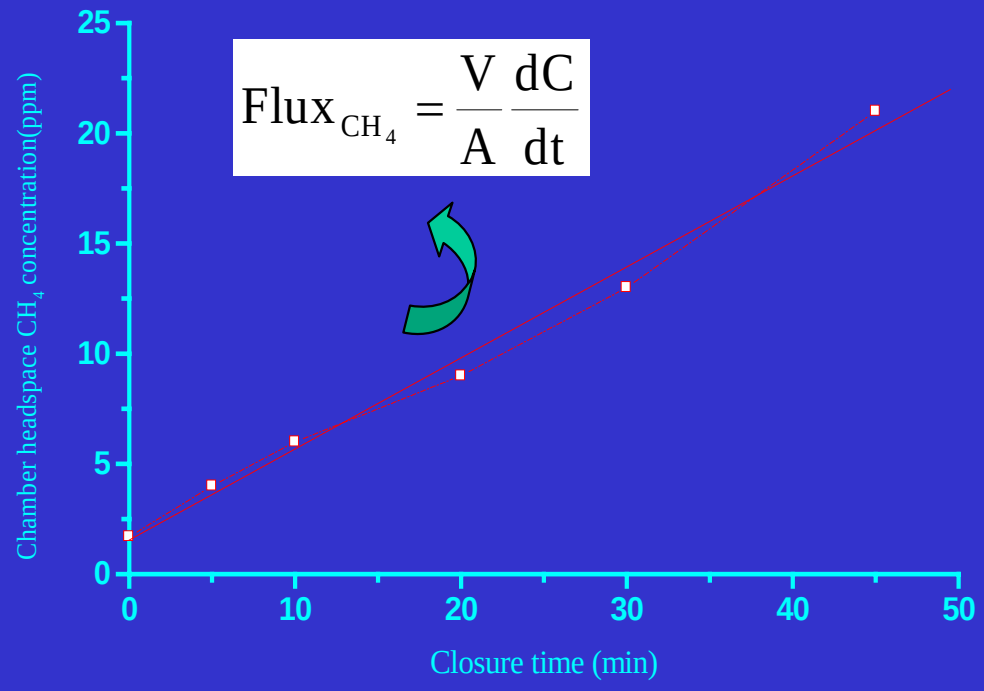
Methane Emission from Rice Paddy in Thailand

- **Link to main economic activity (rice production) and majority of population well-being.**
- **Room to improve emission inventory;**
  - ➔ **area covering**
  - ➔ **temporal variations**
  - ➔ **cultivation practices: organic/inorganic fertilization, water management, seasons.**

Method for Emission Measurements

➔ Static Chamber methods

$$\text{Flux}_{CH_4} = \frac{V}{A}\frac{dC}{dt}$$



Current Procedures

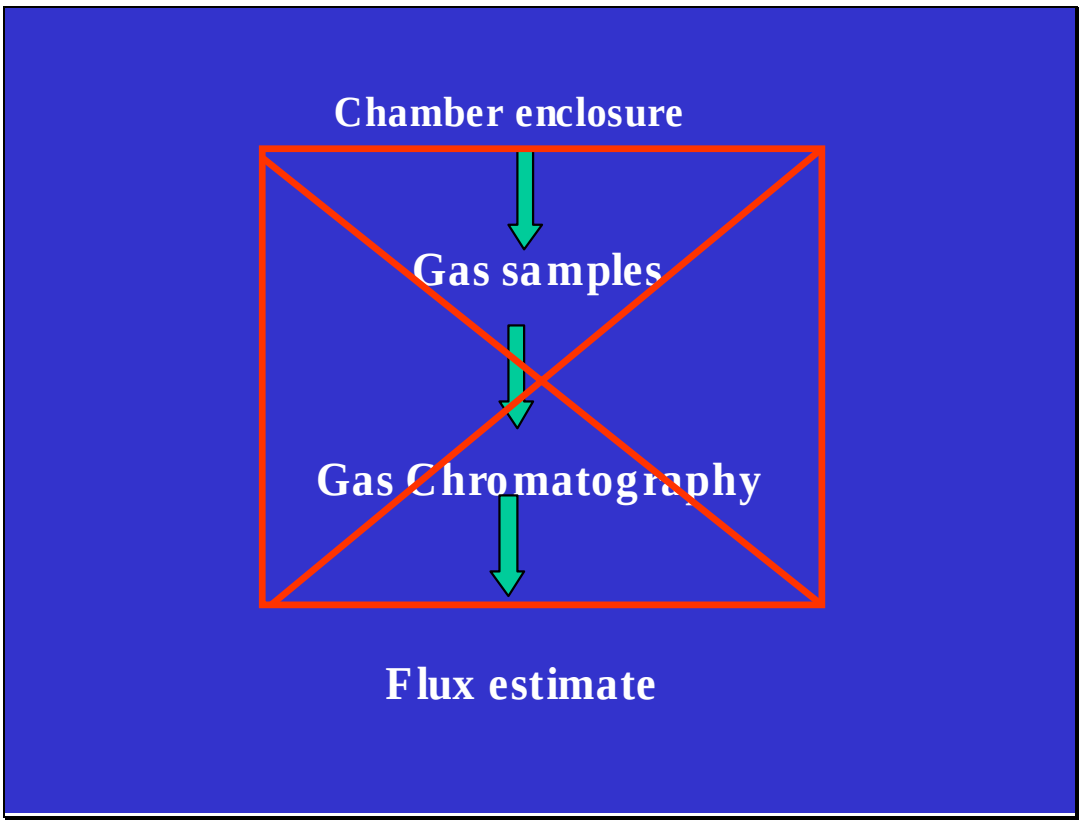
Chamber enclosure

Gas samples

Gas Chromatography

Flux estimate

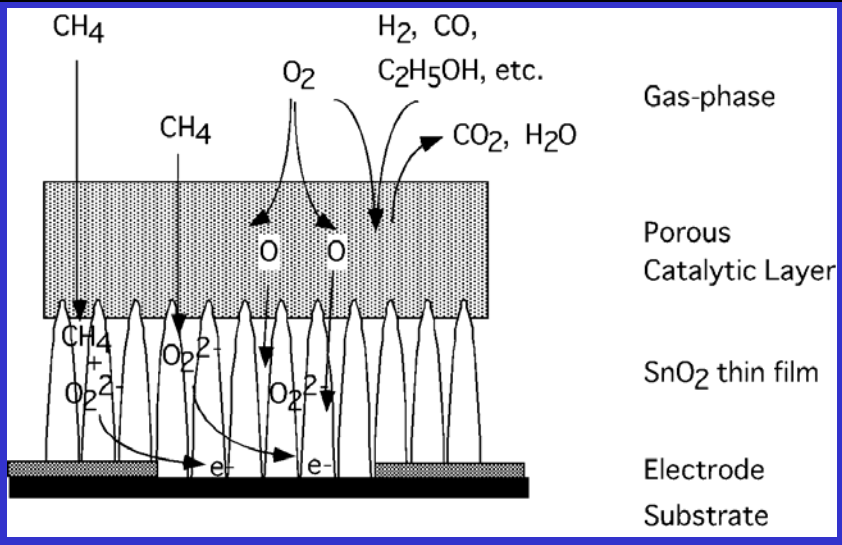
- Time consuming
- Limited replication
- Expensive
- Accuracy concerns
- Not applicable in the remote area



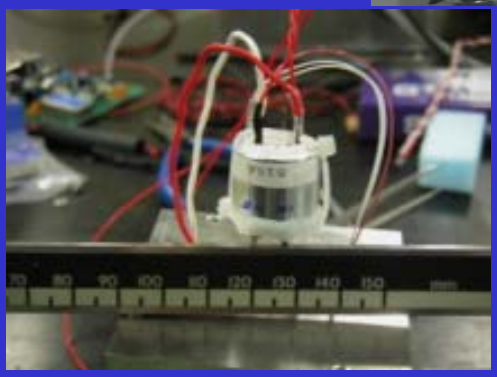
Training: Determination of CH_4 Concentration using semiconductor sensor at NIES

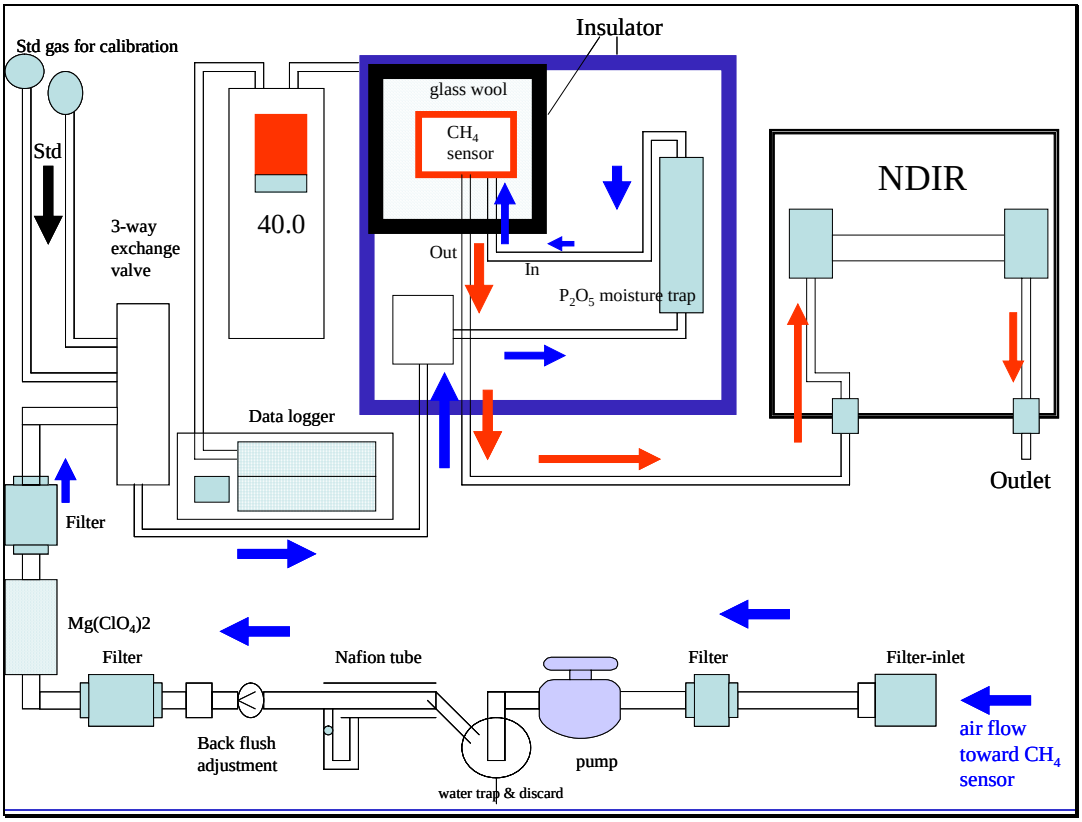
- To learn how to use the CH_4 sensor unit for determining CH_4 concentration.
- 1-30 March 2004, 15-31 August 2004

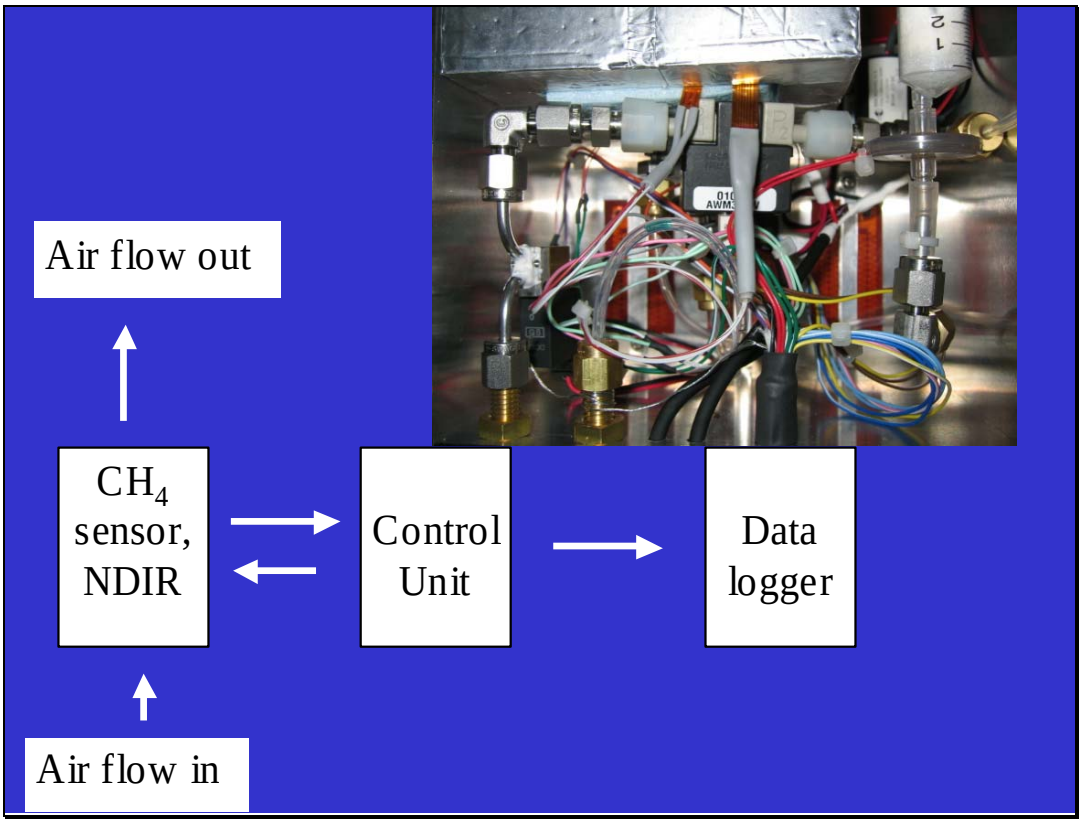
Sensing Mechanism



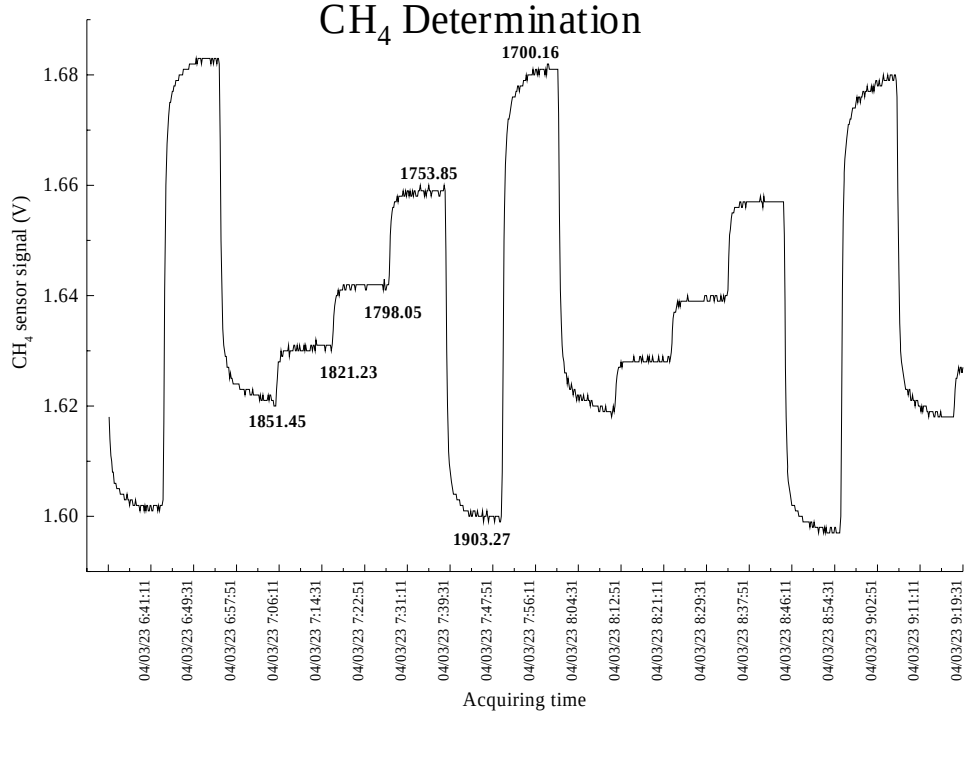
Conductiv $R+O_2^{2-} \rightarrow RO+2e^-$ ons are released; proportional to the amount of reduced gas

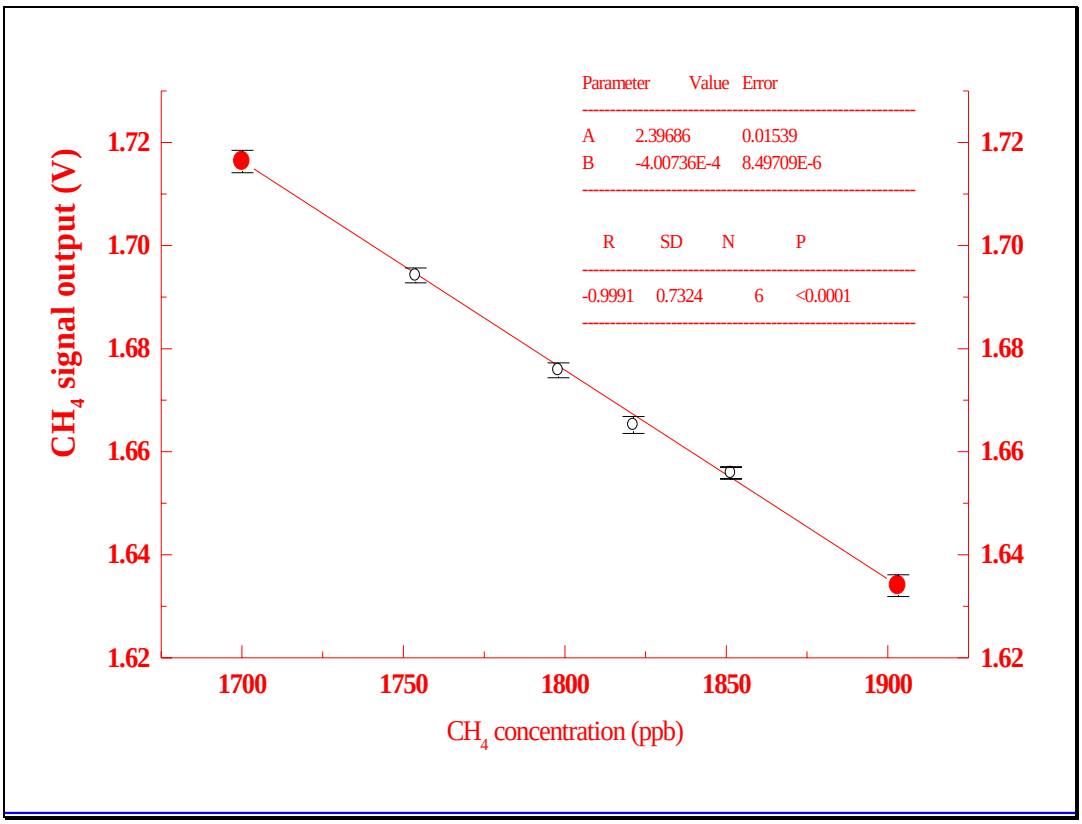



Std gas for calibration
Std
3-way exchange valve
40.0
Insulator
glass wool
CH_4 sensor
Out
In
P_2O_5 moisture trap
NDIR
Outlet
Data logger
Filter
$Mg(ClO_4)2$
Filter
Nafion tube
Filter
Filter-inlet
Back flush adjustment
water trap & discard
pump
air flow toward CH_4 sensor

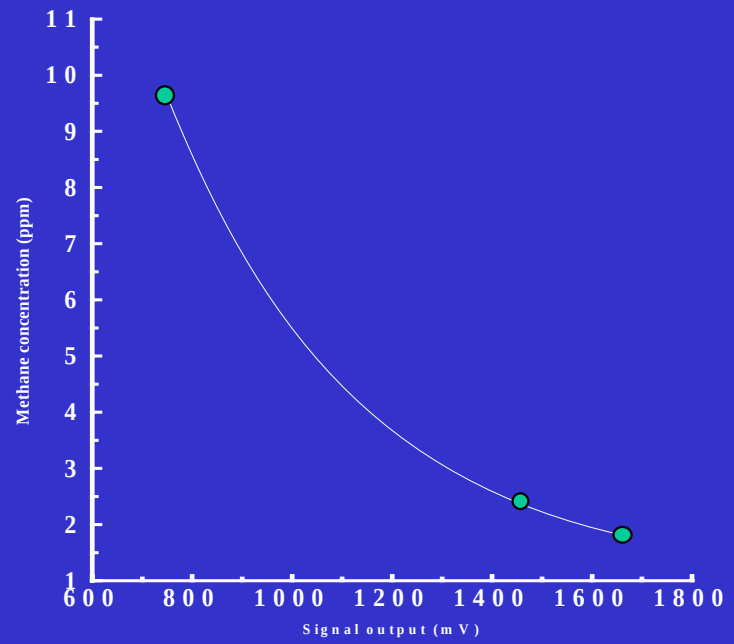

Air flow out
CH_4 sensor, NDIR
Control Unit
Data logger
Air flow in

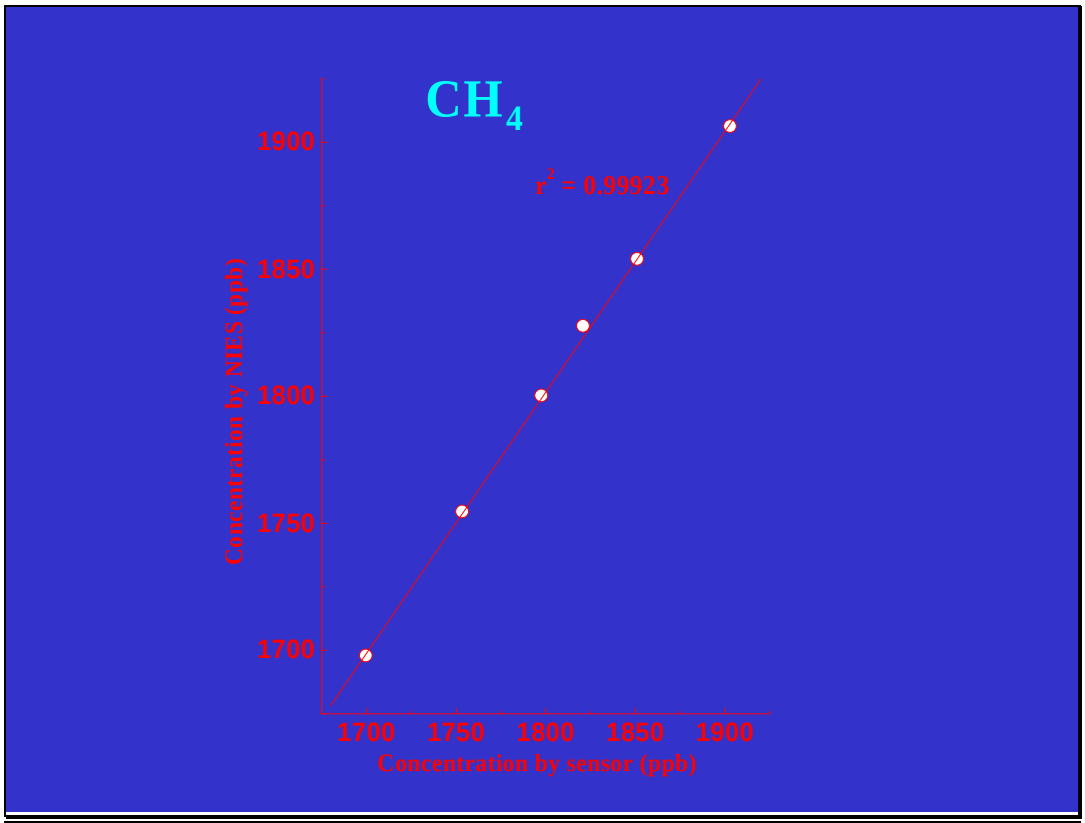
Sensor Mobile Unit

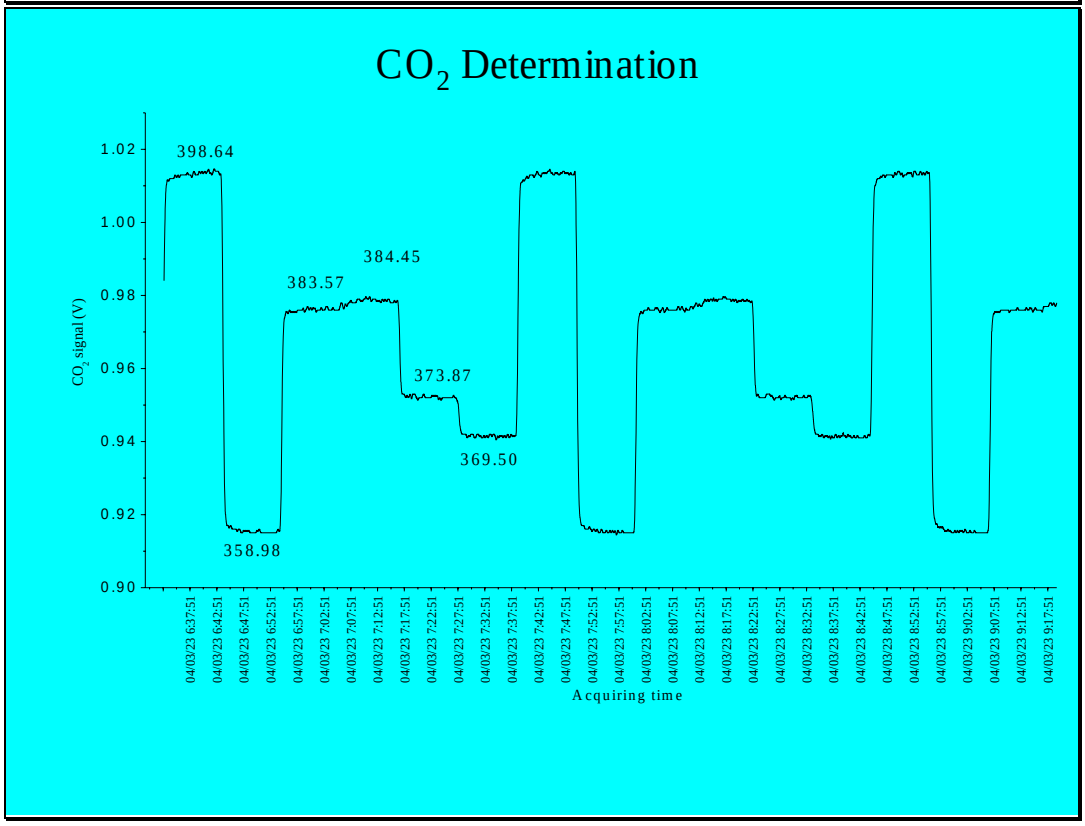


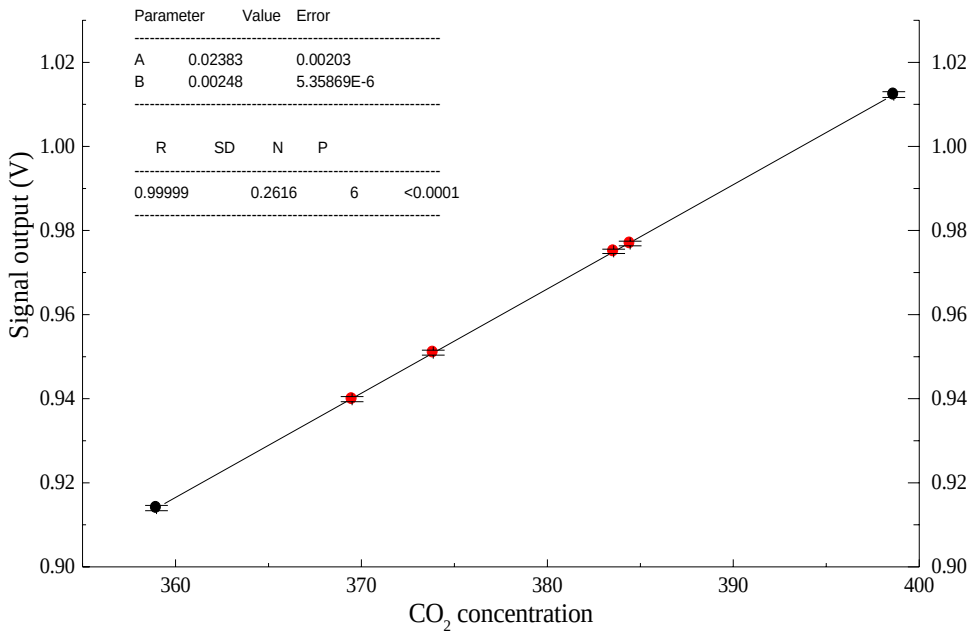


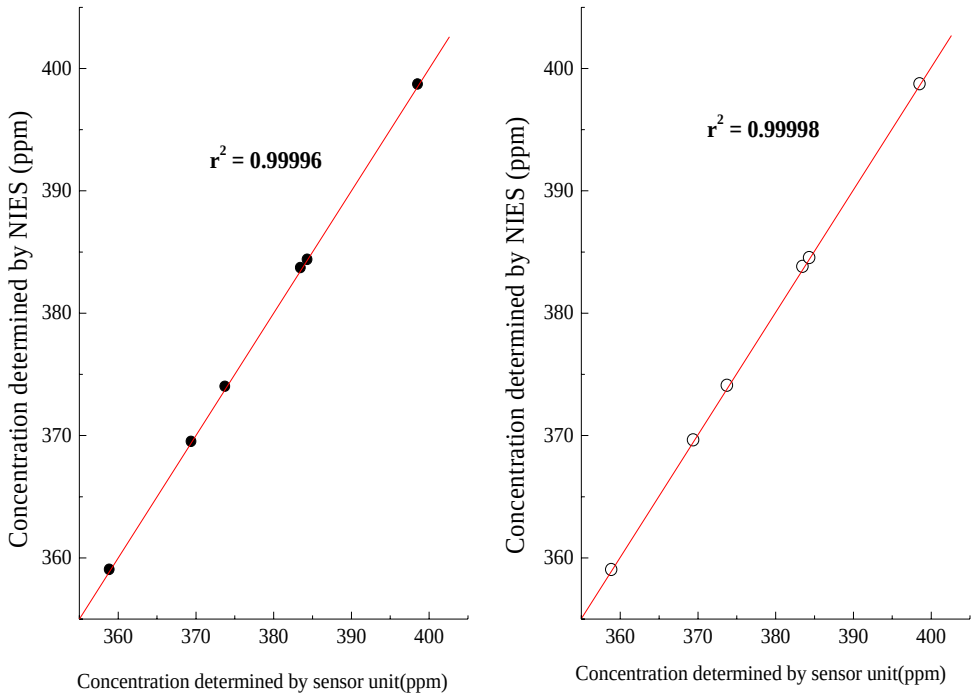
Measurement Range



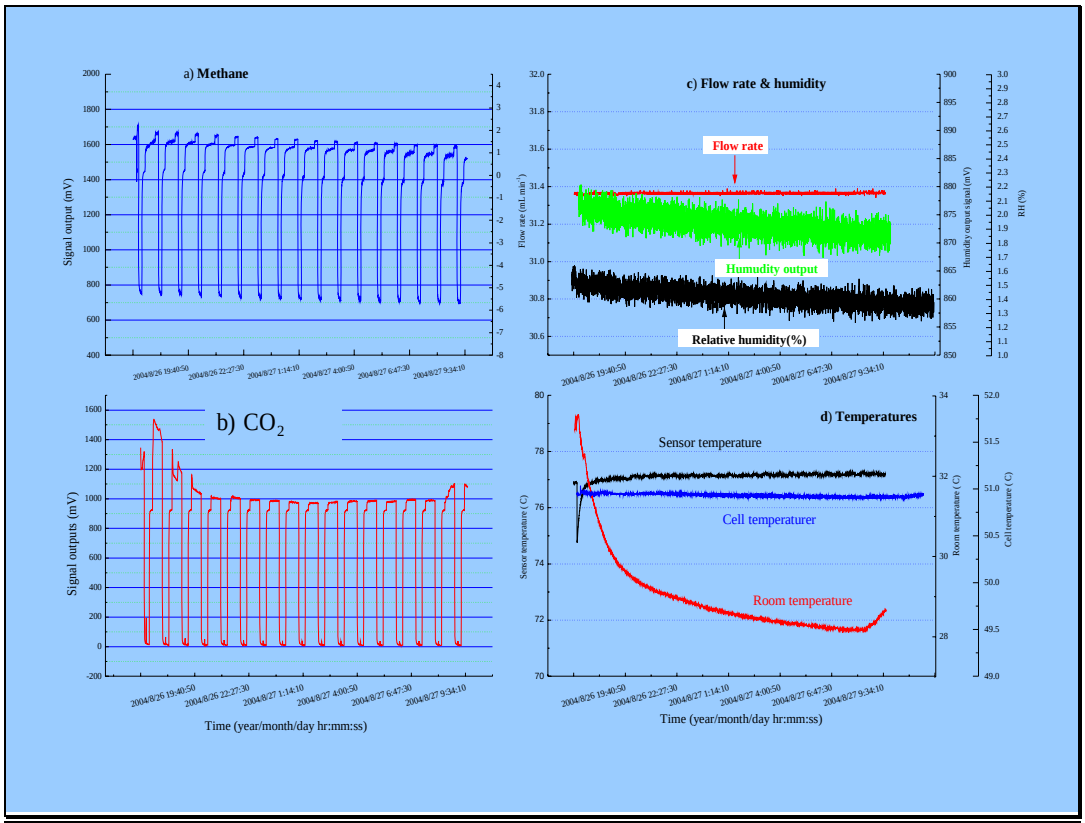

CH4
r2 = 0.99923
Concentration by NIES (ppb)
1900
1850
1800
1750
1700
1700
1750
1800
1850
1900
Concentration by sensor (ppb)

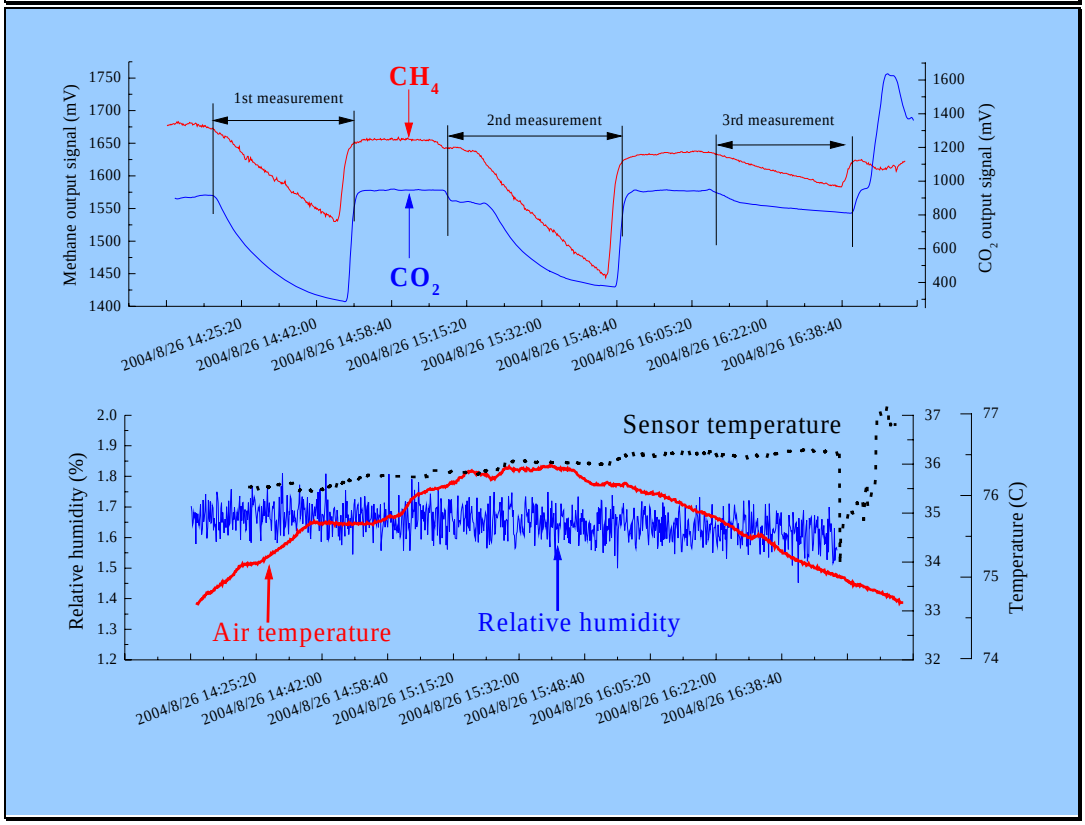

CO2 Determination
398.64
384.45
383.57
373.87
369.50
358.98
CO2 signal (V)
1.02
1.00
0.98
0.96
0.94
0.92
0.90
Acquiring time


Parameter Value Error
A 0.02383 0.00203
B 0.00248 5.35869E-6
R SD N P
0.99999 0.2616 6 <0.0001
Signal output (V)
CO2 concentration
1.02
1.00
0.98
0.96
0.94
0.92
0.90
360
370
380
390
400

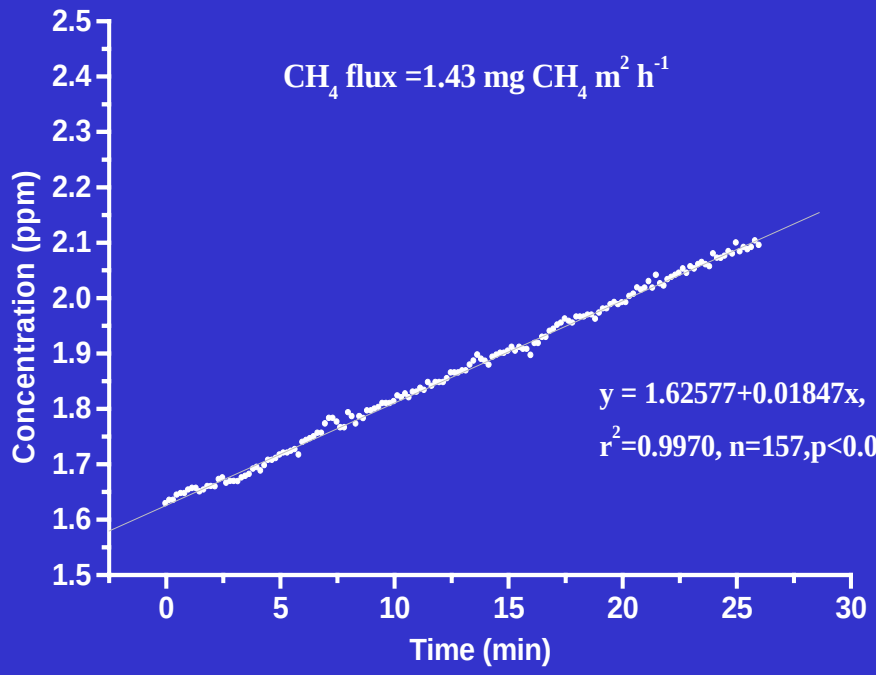

r2 = 0.99996
Concentration determined by NIES (ppm)
Concentration determined by sensor unit(ppm)
r2 = 0.99998
Concentration determined by NIES (ppm)
Concentration determined by sensor unit(ppm)
400
390
380
370
360

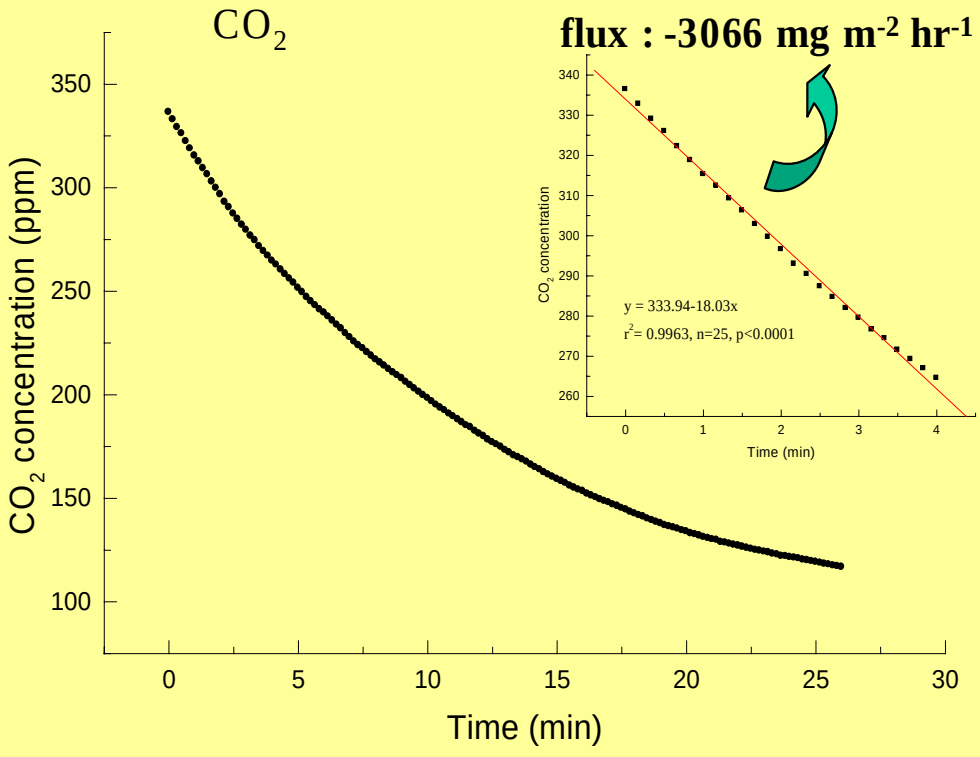
Field Deployment


a) Methane
Signal output (mV)
c) Flow rate & humidity
Flow rate
Humudity output
Relative humidity(%)
Flow rate (mL min⁻¹)
Humidity output signal (mV)
RH (%)
b) CO2
Signal outputs (mV)
d) Temperatures
Sensor temperature
Cell temperaturer
Room temperature
Sensor temperature (C)
Room temperature (C)
Cell temperature (C)
Time (year/month/day hr:mm:ss)
Time (year/month/day hr:mm:ss)


CH4
1st measurement
2nd measurement
3rd measurement
CO2
Methane output signal (mV)
CO2 output signal (mV)
Sensor temperature
Air temperature
Relative humidity
Relative humidity (%)
Temperature (C)

Methane Flux





- The sensor unit:
- ➔ mobile, no need for external power supply
- ➔ quick measurement, reliable, accurate
- ➔ many measurement replications
- ➔ cheaper cost per measurement
- ➔ relatively easy to operate

What's next?

➔ Use for CH_4 emission measurement in Thai paddies

➔ Comparing with the conventional chamber-GC method

➔ Apply in various rice cultivation schemes

➔ Emission factor database for CH_4 emission in Thailand

➔ Application in other countries

Thanks

- NIES GHG Inventory Team--Japan
- Joint Graduate School of Energy & Environment (JGSEE), King Mongkut's Univ. of Technology Thonburi---Thailand
- APN—Financial supports