An inventory of CH_4 emission from rice paddies in China based on Tier 3 approaches

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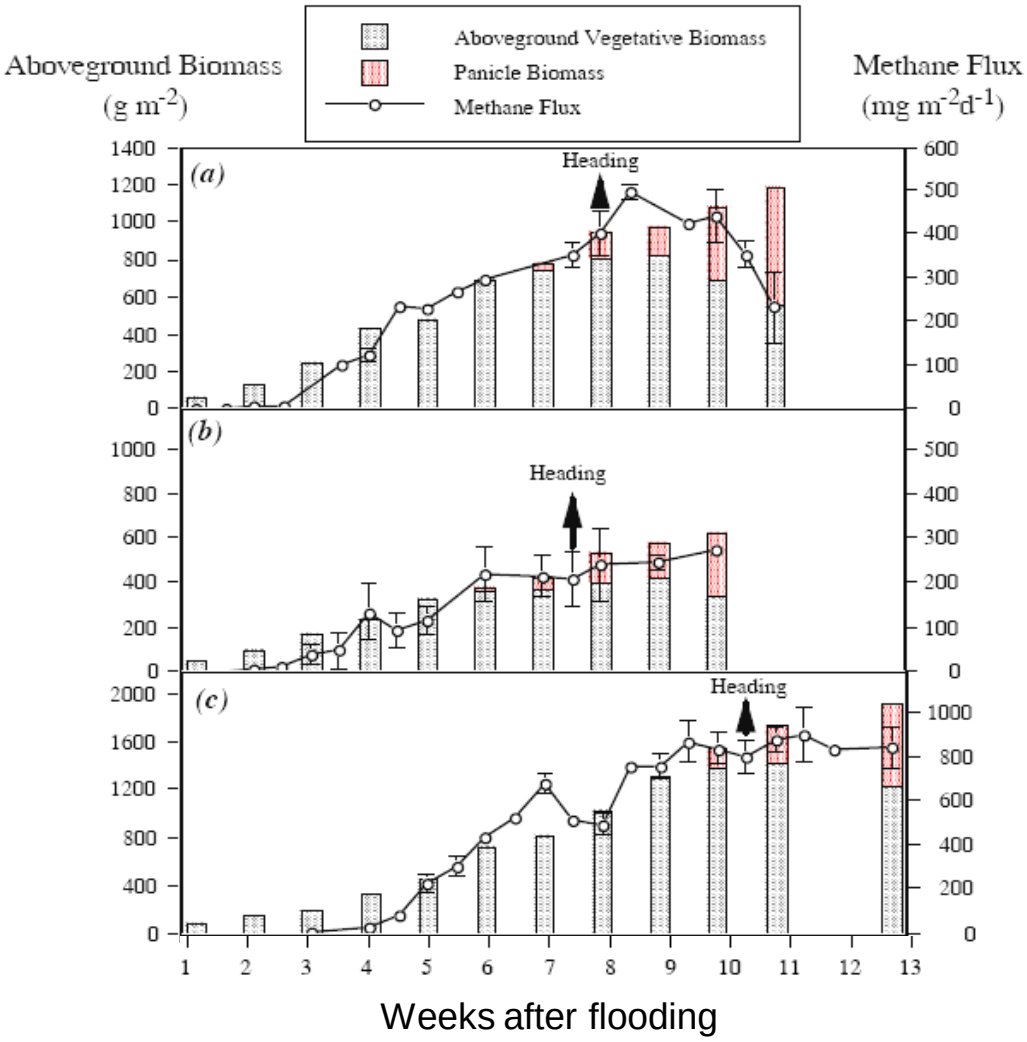
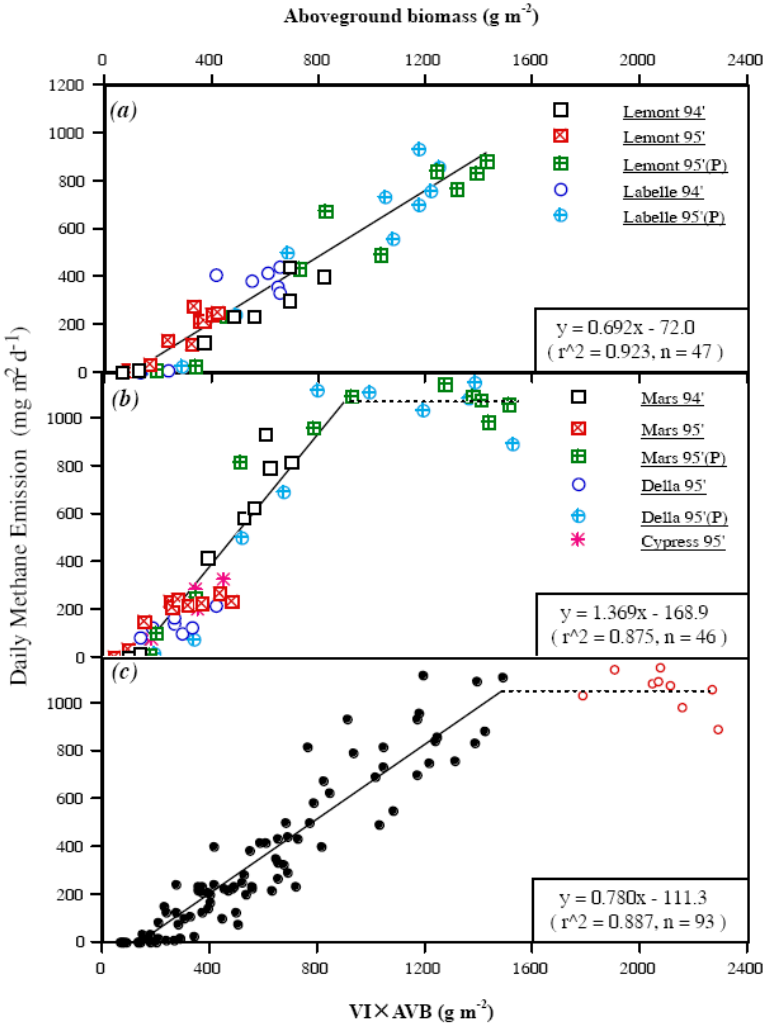
Key drivers of rice paddy CH_4

- Rice growth
- Organic matter amendment
- Water regime
- Temperature
- Soil texture

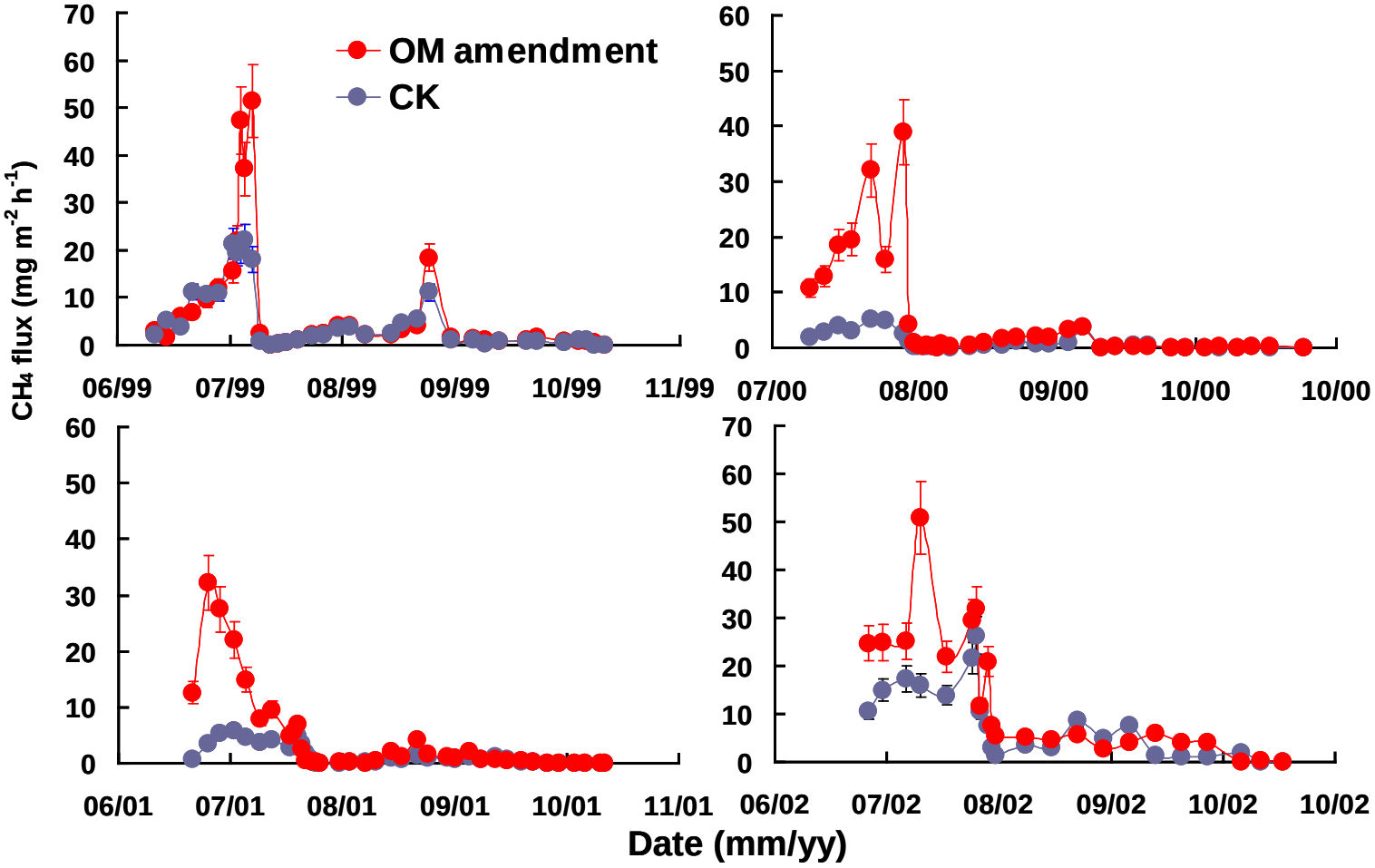
CH_4 emission vs. rice growth





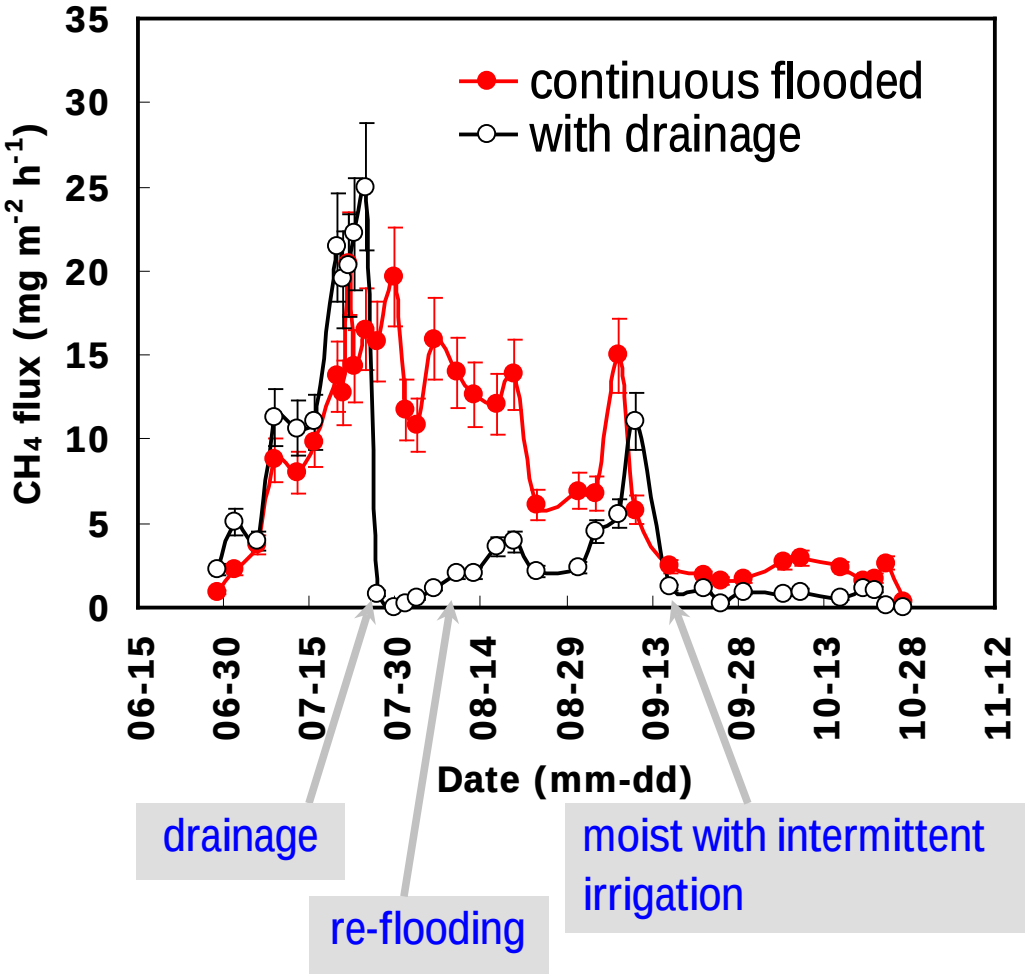
(Huang *et al.*, *Global Change Biology*, 1997)

CH_4 emission vs. OM amendment

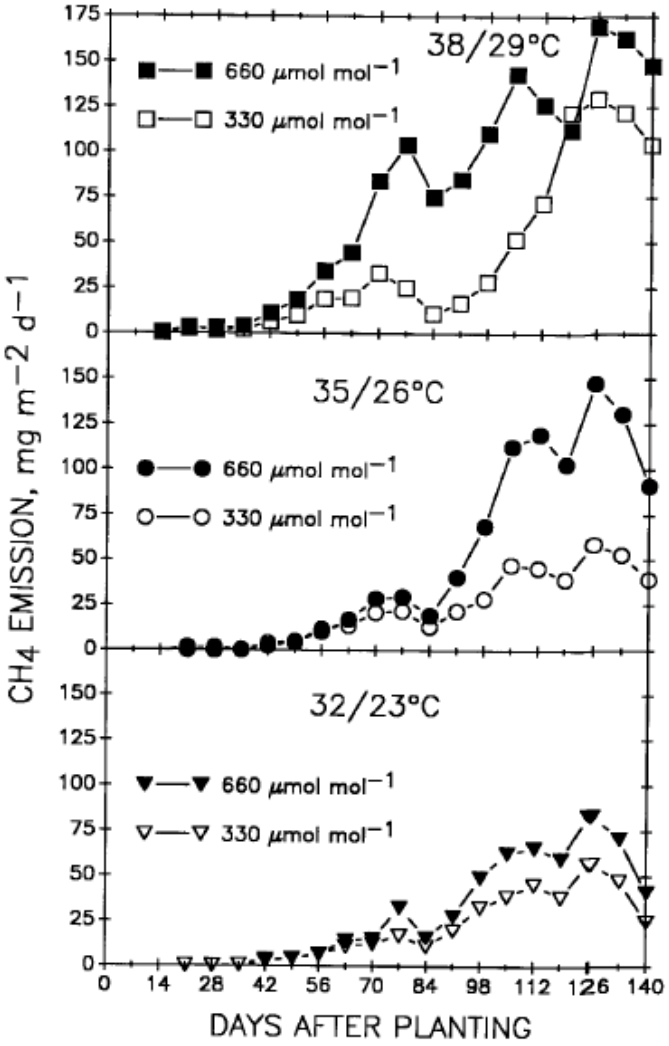


CH_4 emission from rice paddy in 1999-2002 rice-growing seasons (Nanjing, 31°52'N, 118°50'E)

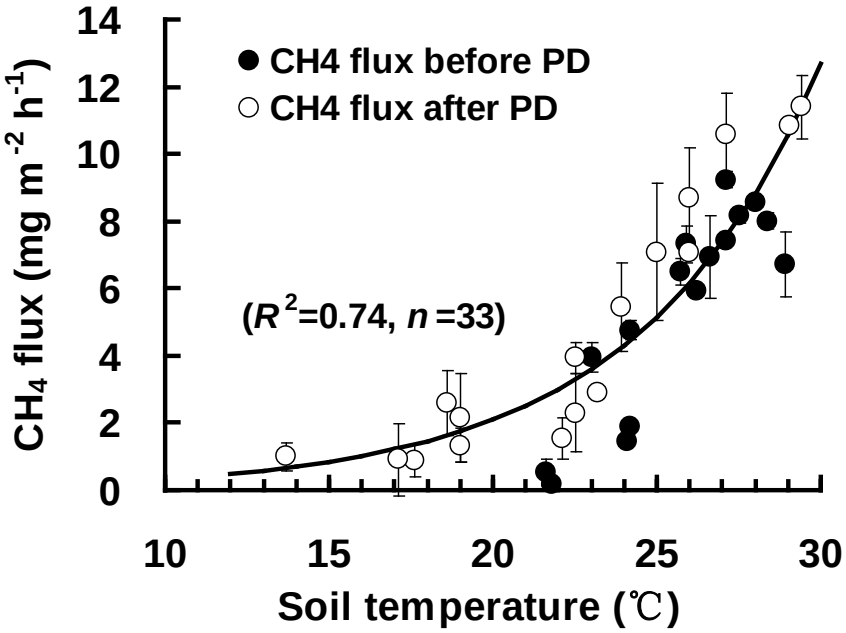
CH_4 emission vs. water regime



CH_4 emission vs. temperature



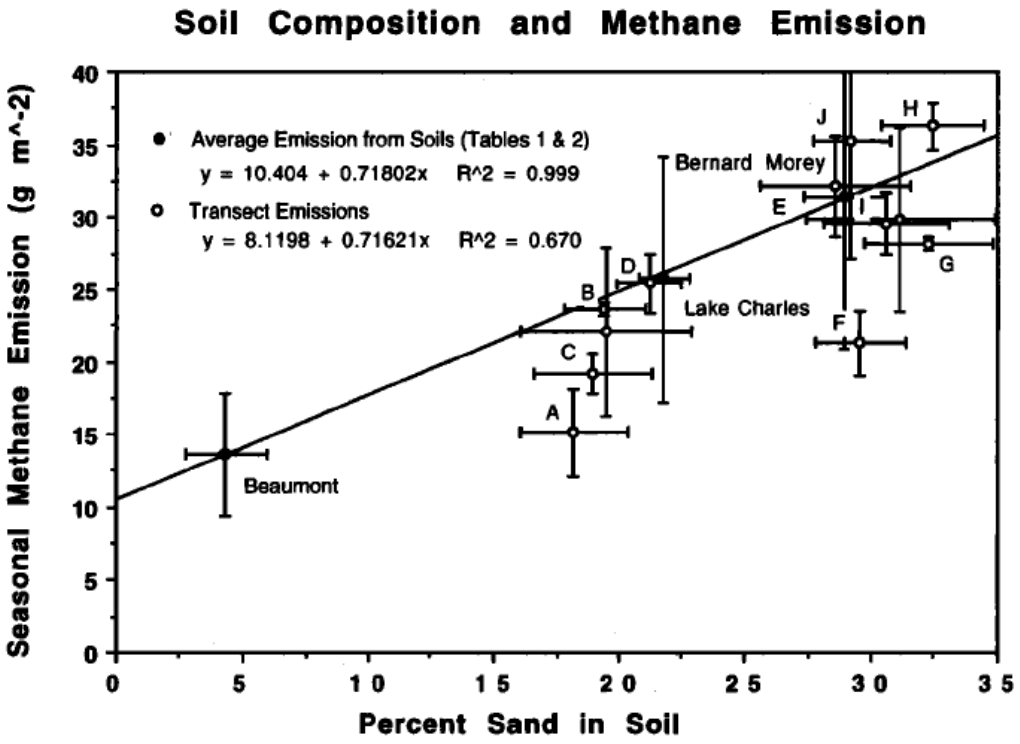
(Allen *et al*., 2003)



continuous flooded, Nanjing

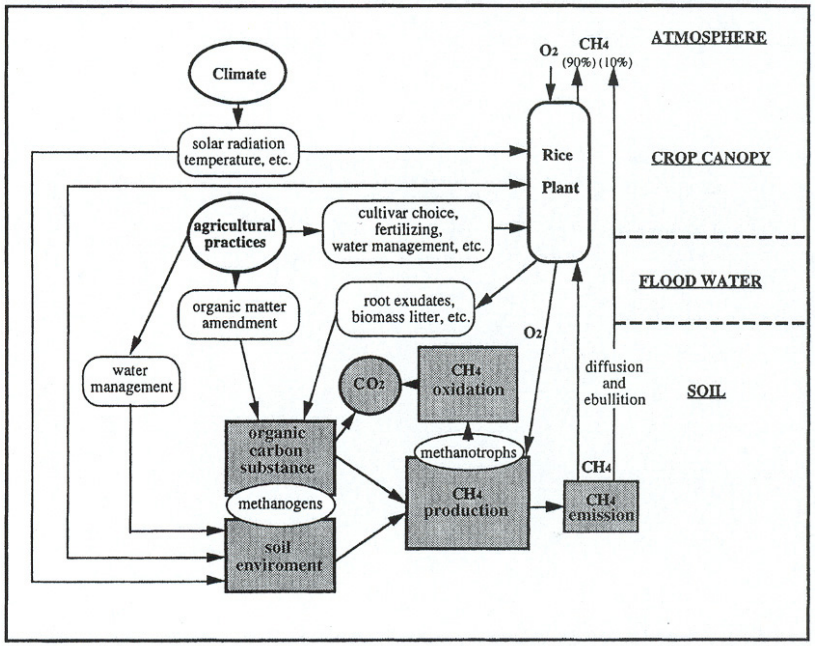
(Huang *et al*., 2001)

CH_4 emission vs. soil texture



(Sass *et al.*, 1994)

CH4MOD:
Modeling CH_4 emission from rice paddies



CH_4 production

$$\frac{dP}{dt} = \alpha F_{Eh} \times SI \times TI \times [\beta \frac{dC_R}{dt} + \gamma \frac{dC_{OM}}{dt}]$$

CH_4 emission

$$F_p = 0.55 \times (1 - \frac{W}{W_{\max}})^{0.25}$$

$$E_{bl} = 0.7 \times (P - P_{\ }) \times \frac{\ln(T_{soil})}{W_{root}}$$

Soil Eh

$$\begin{cases} Eh^{(t+1)} = Eh^{(t)} - D_{Eh} \times (A_{Eh} + \min(1, C_{OM})) \times (Eh^{(t)} - B_{Eh}) \\ Eh^{(t+1)} = Eh^{(t)} - D_{Eh} \times (A_{Eh} + 0.7) \times (Eh^{(t)} - B_{Eh}) \end{cases}$$

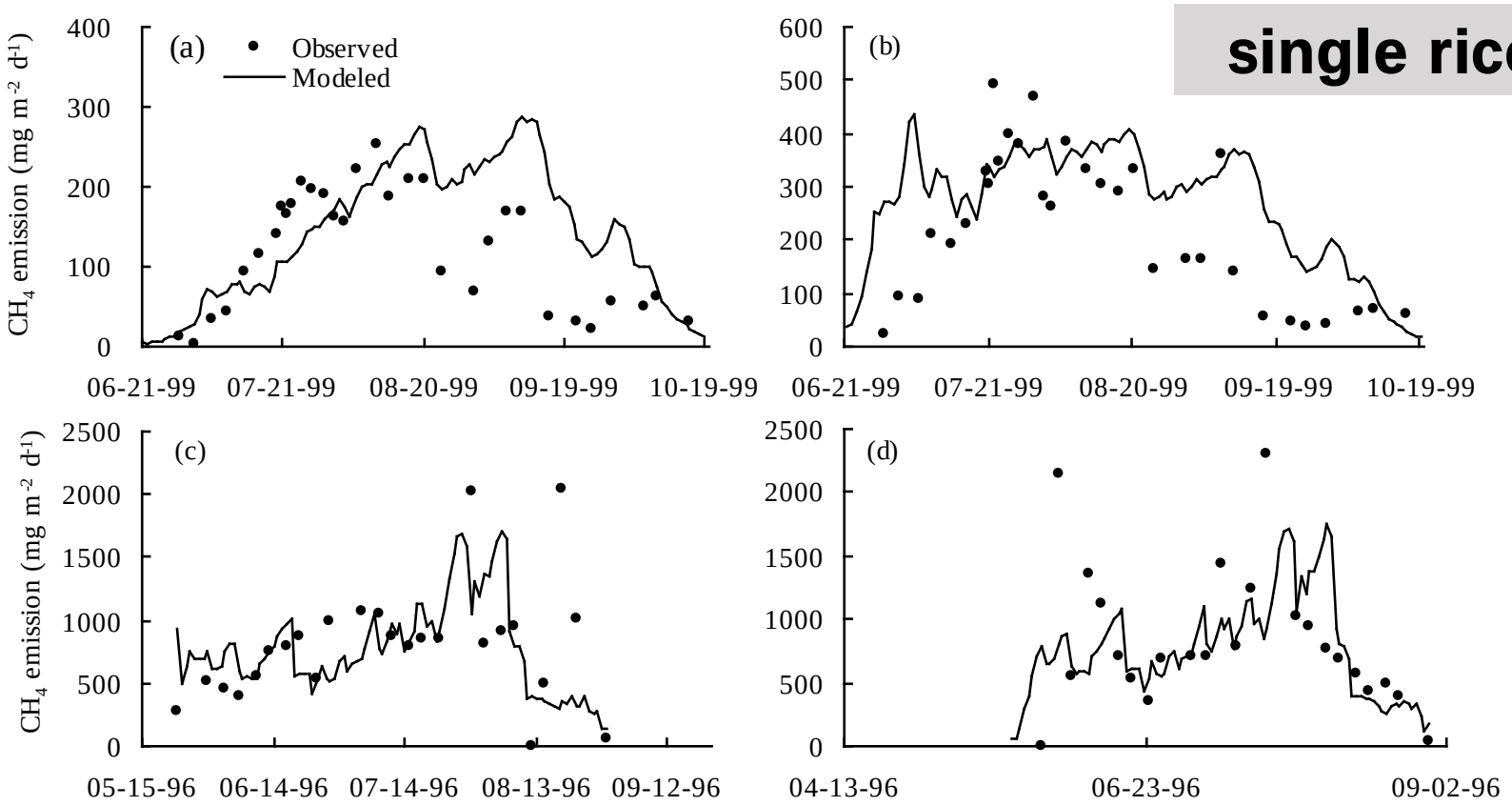
(Huang *et al.*, *Global Change Biology*, 1998; Huang *et al.*, *J. of Geophysical Research*, 2004)

CH4MOD:

Model validation against independent field measurements

Observational Site (City or County/Province)		Location	Soil texture /Sand%	Rice cultivation	No. cases
Guangzhou /Guangdong	S	23°08´N 113°20´E	Sandy loam /46.3	Double	4
Changsha /Hunan		28°09´N 113°06´E	Sandy loam /62.0	Double	20
Taoyuan /Hunan		28°55´N 110°30´E	Silty loam /21.2	Double	8
Tuzu /Sichuan		29°40´N 103°50´E	Sandy /78.5	Single	7
Chongqing /Chongqing		29°48´N 106°18´E	Sandy /57.0	Single	11
Hangzhou /Zhejiang		30°19´N 120°12´E	Loam /23.0	Single Double	7 16
Nanjing /Jiangsu		31°51´N 118°49´E	Clayey /4.8	Single	4
Fengqiu /Henan		35°24´N 114°24´E	Clayey/2.0 Loam /20.0 Sandy/80.0	Single	6
Beijing /Beijing	N	40°30´N 116°25´E	Sandy/55.0	Single	11

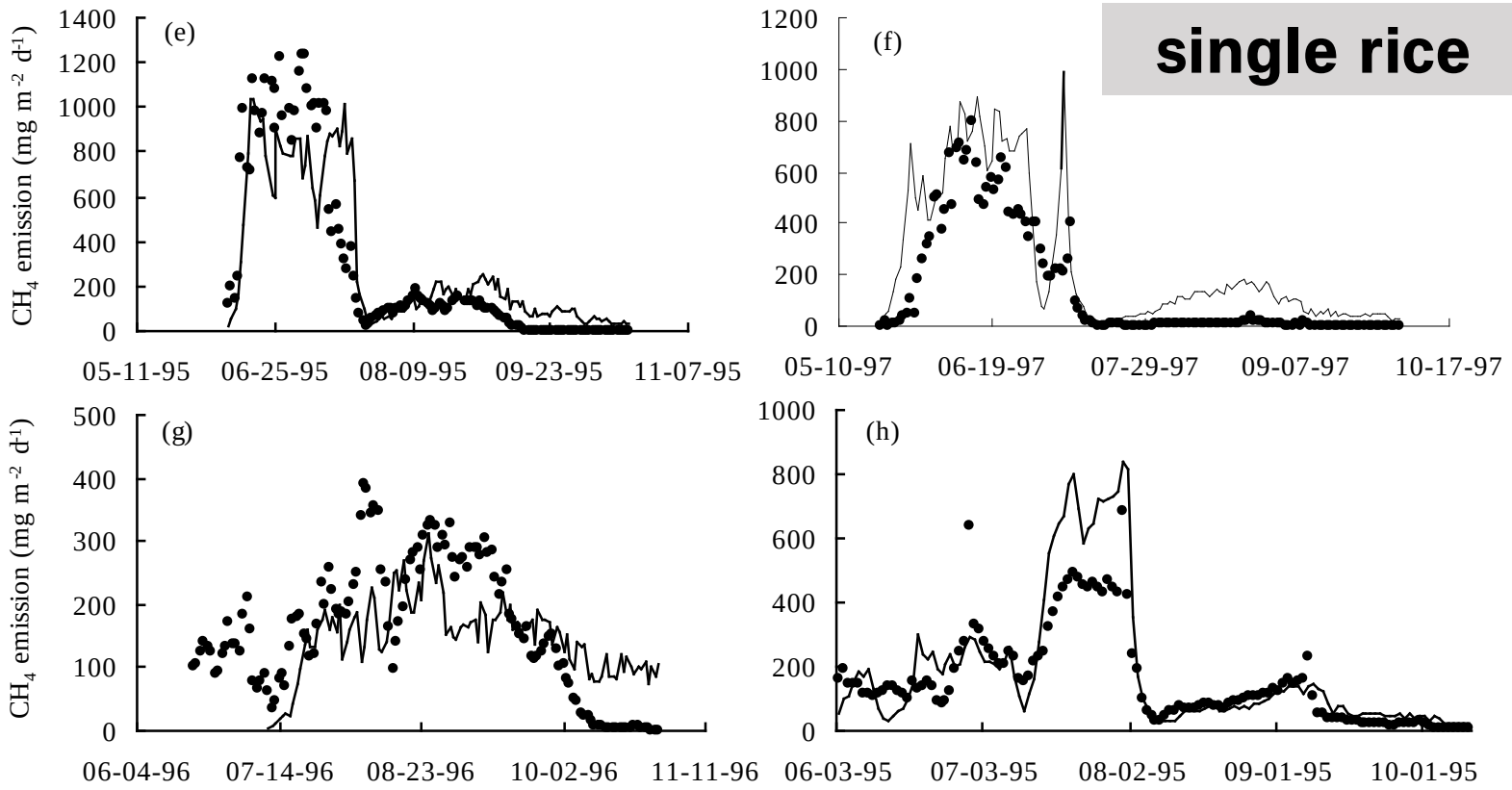
CH4MOD: Model validation



(a) Nanjing (31º51'N, 118º49'E) , wheat/rice, no OM;
(b) Nanjing (31º51'N, 118º49'E), wheat/rice, wheat straw 4.5t/ha;
(c) Chongqing (29º48'N, 106º18'E), waterlog/rice, FYM 5.0t/ha;
(d) Chongqing (29º48'N, 106º18'E), wheat/rice, FYM 5.0t/ha.

(Huang *et al., J. of Geophysical Research,* 2004)

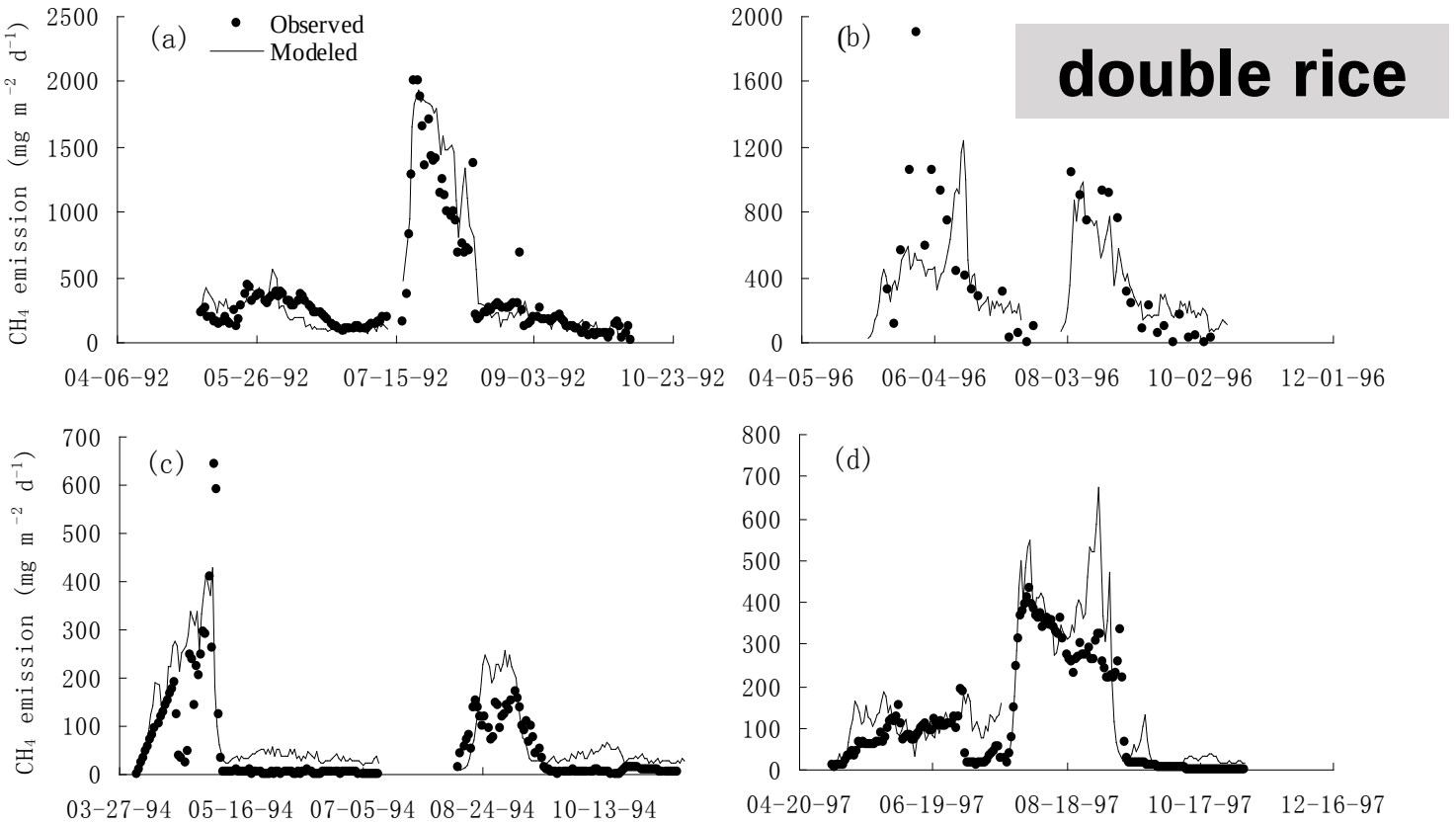
CH4MOD: Model validation



(e) Beijing (40º30'N, 116º25'E), winter fallow/rice, PM 3.6t/ha;
(f) Beijing (40º30'N, 116º25'E), winter fallow/rice, rice straw 2.6t /ha;
(g) Hangzhou (30º19'N, 120º12'E), wheat/rice, no OM;
(h) Hangzhou (30º19'N, 120º12'E), wheat/rice, GM 1.1t/ha.

(Huang *et al., J. of Geophysical Research*, 2004)

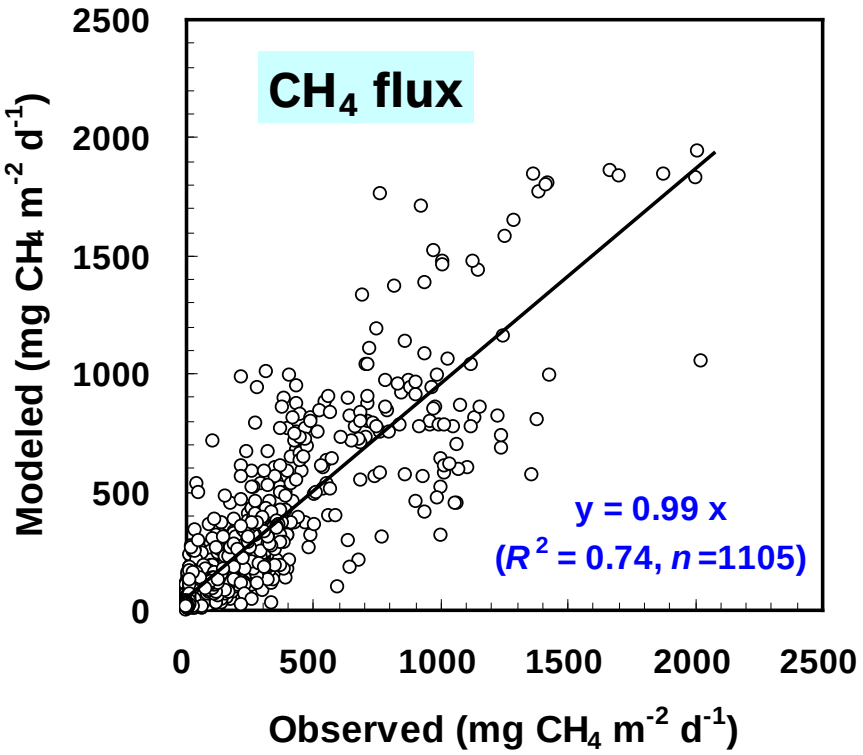
CH4MOD: Model validation

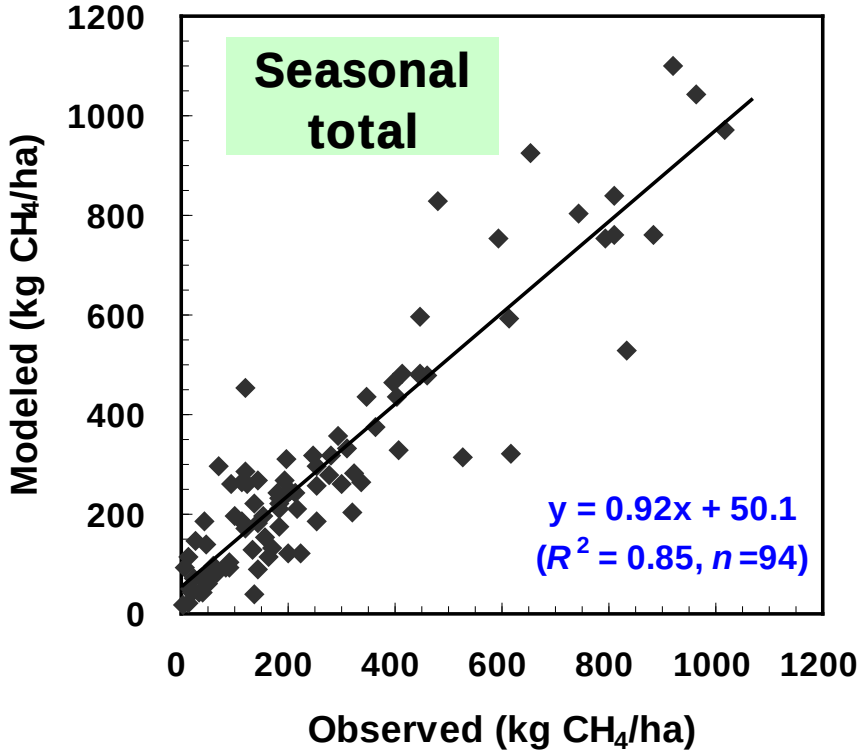


(a) Taoyuan (28º55'N, 110º30'E), early-rice: GM 3t/ha; late-rice: rice straw 4.5t/ha;
(b) Changsha (28º09'N, 113º06'E), early-rice: wild weeds 0.46t/ha; late-rice: no OM;
(c) Guangzhou (23º08'N, 113º20'E), early-rice: FYM 3t/ha; late-rice: no OM;
(d) Hangzhou (30º19'N, 120º12'E), early-rice & late-rice, bio-gas residual 0.6t/ha.

(Huang *et al., J. of Geophysical Research,* 2004)

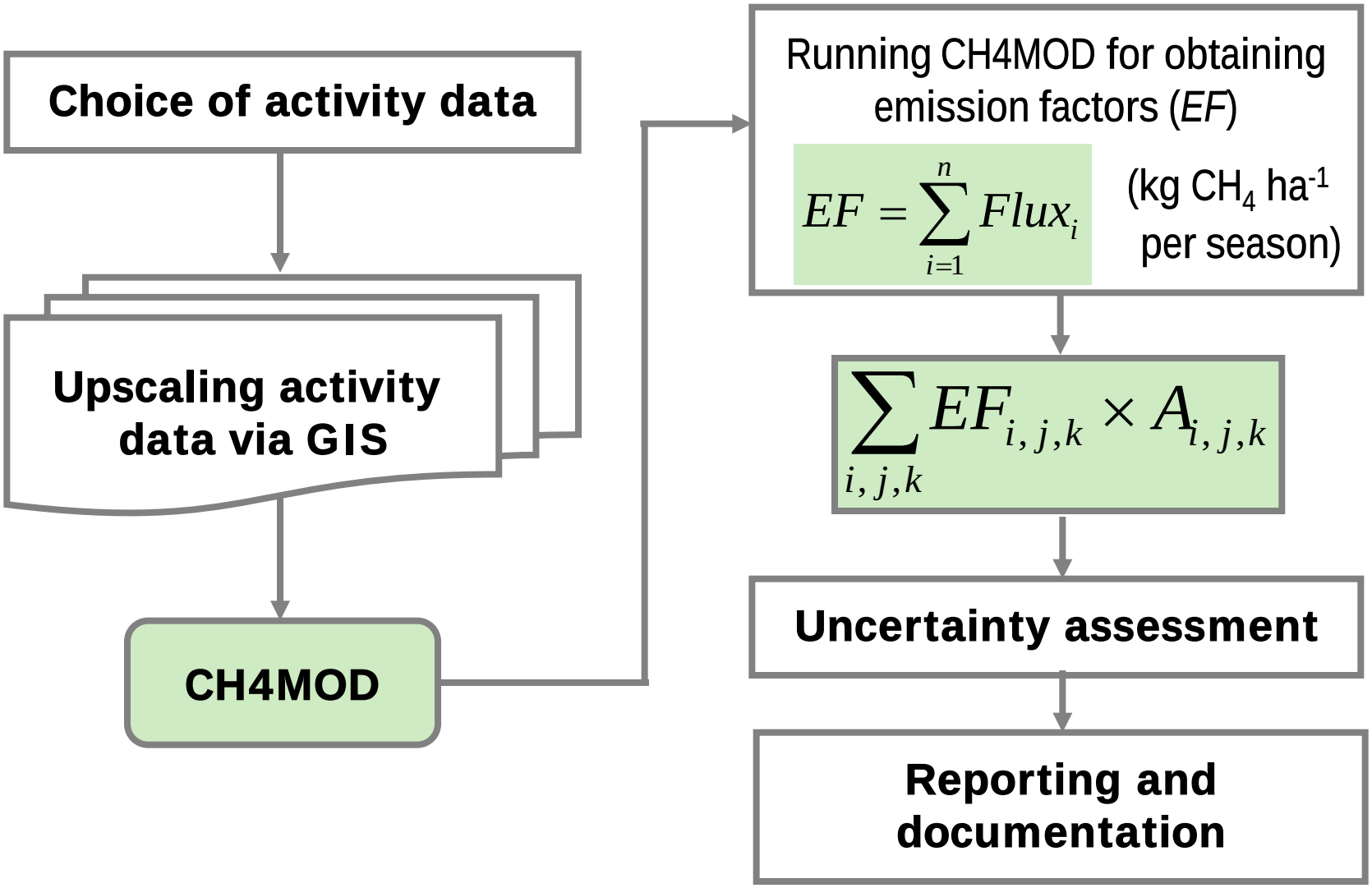
CH4MOD: Model validation





(Huang *et al., J. of Geophysical Research*, 2004)

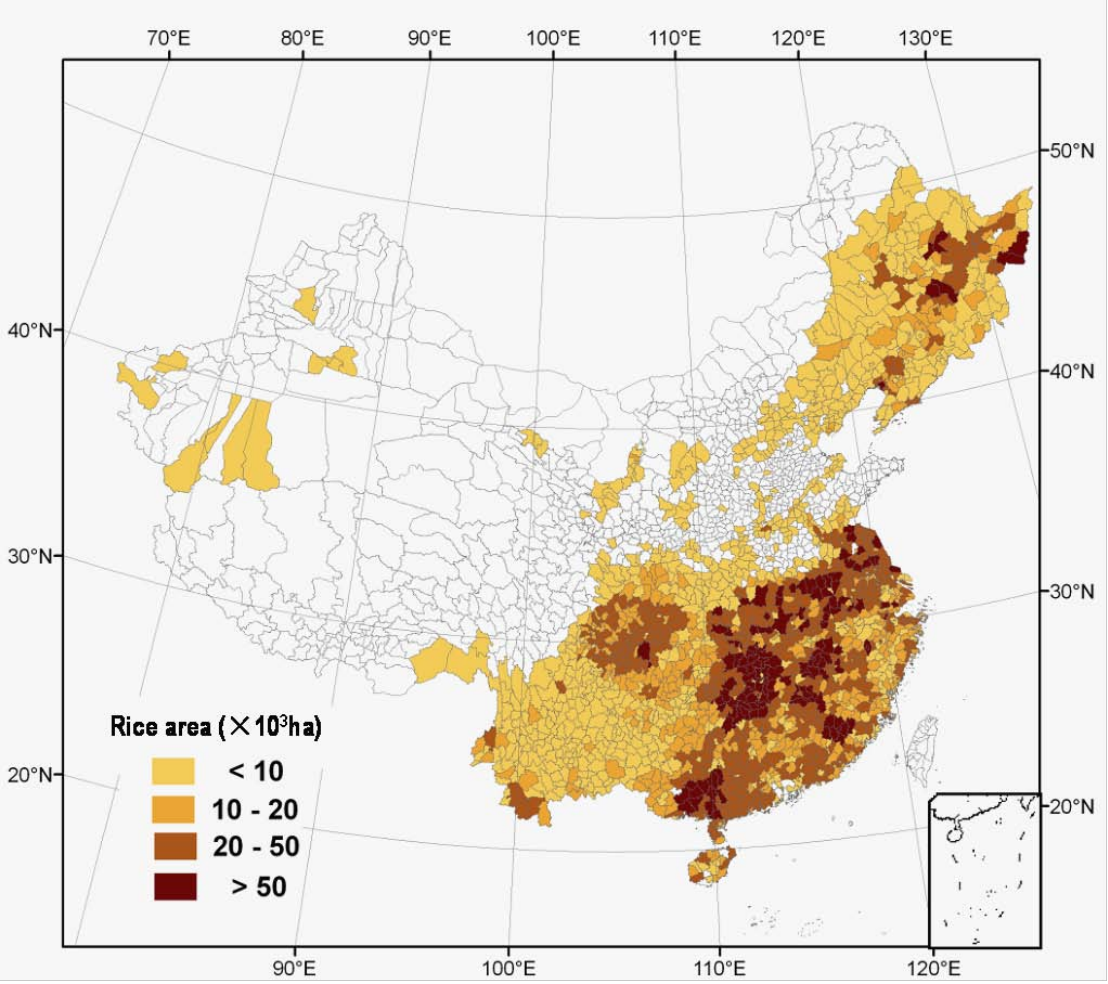
INVENTORY: Working routine



INVENTORY: Activity data/model inputs

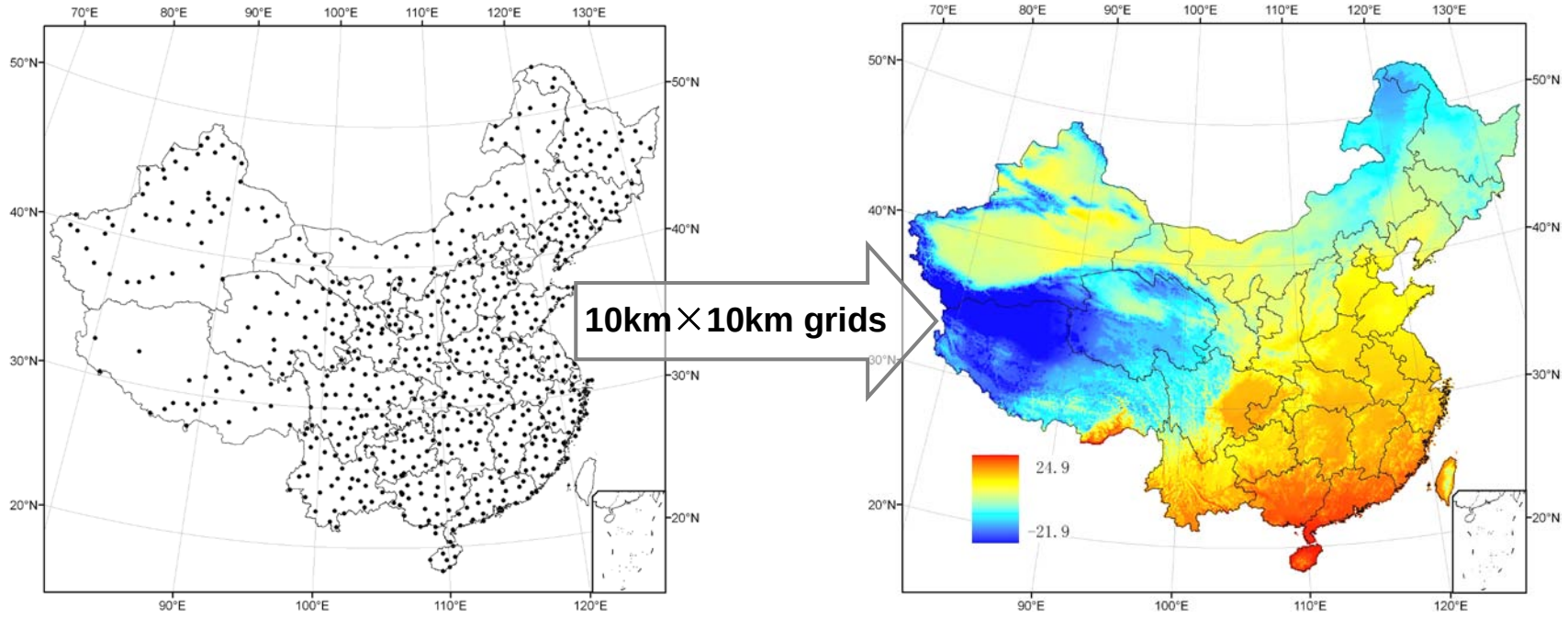
- **Rice cropping practices**
  - Crop rotation & calendar
  - Water regime
  - OM amendment (type and rate)
  - Rice production
- **Soil and climate**
  - Soil sand percentage
  - Daily air temperature

INVENTORY: Activity data/model inputs



Rice planting area in 2000

INVENTORY:
Upscaling activity data via GIS



Distribution of weather observation stations

Spatialized daily temperature

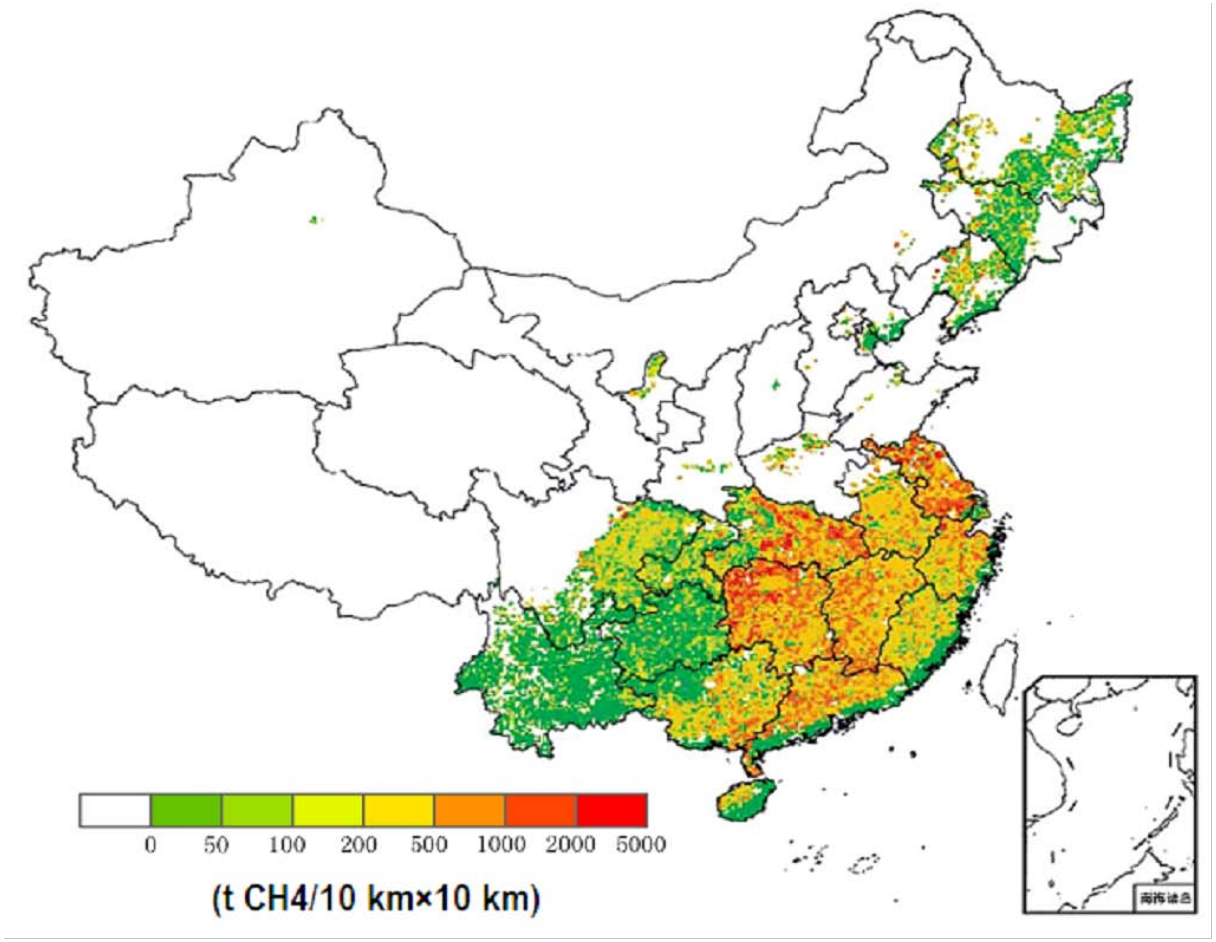
INVENTORY:

CH_4 emission from different rice cropping systems

Rice cultivation	Acreage (Mha)	CH_4 emission (Tg/yr)	Percentage (%)
Early-rice	6.8	1.63	27
Late-rice	7.6	1.46	24
Single-rice	15.7	2.93	49
Total	30.1	6.02	100

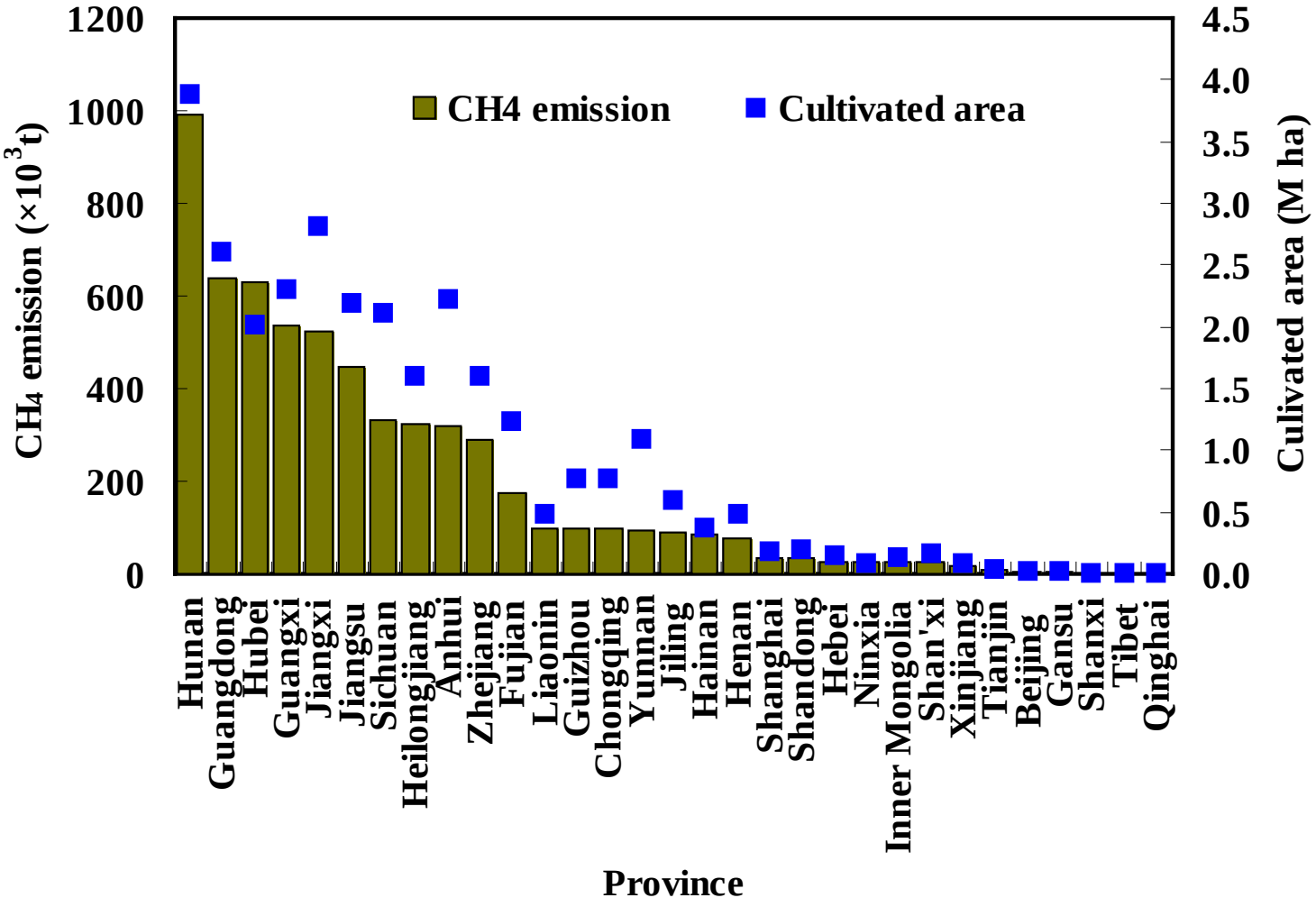
(Huang *et al*, 2006. *ACTA ECOLOGICA SINICA*)

INVENTORY:
Spatial distribution of CH_4 emission

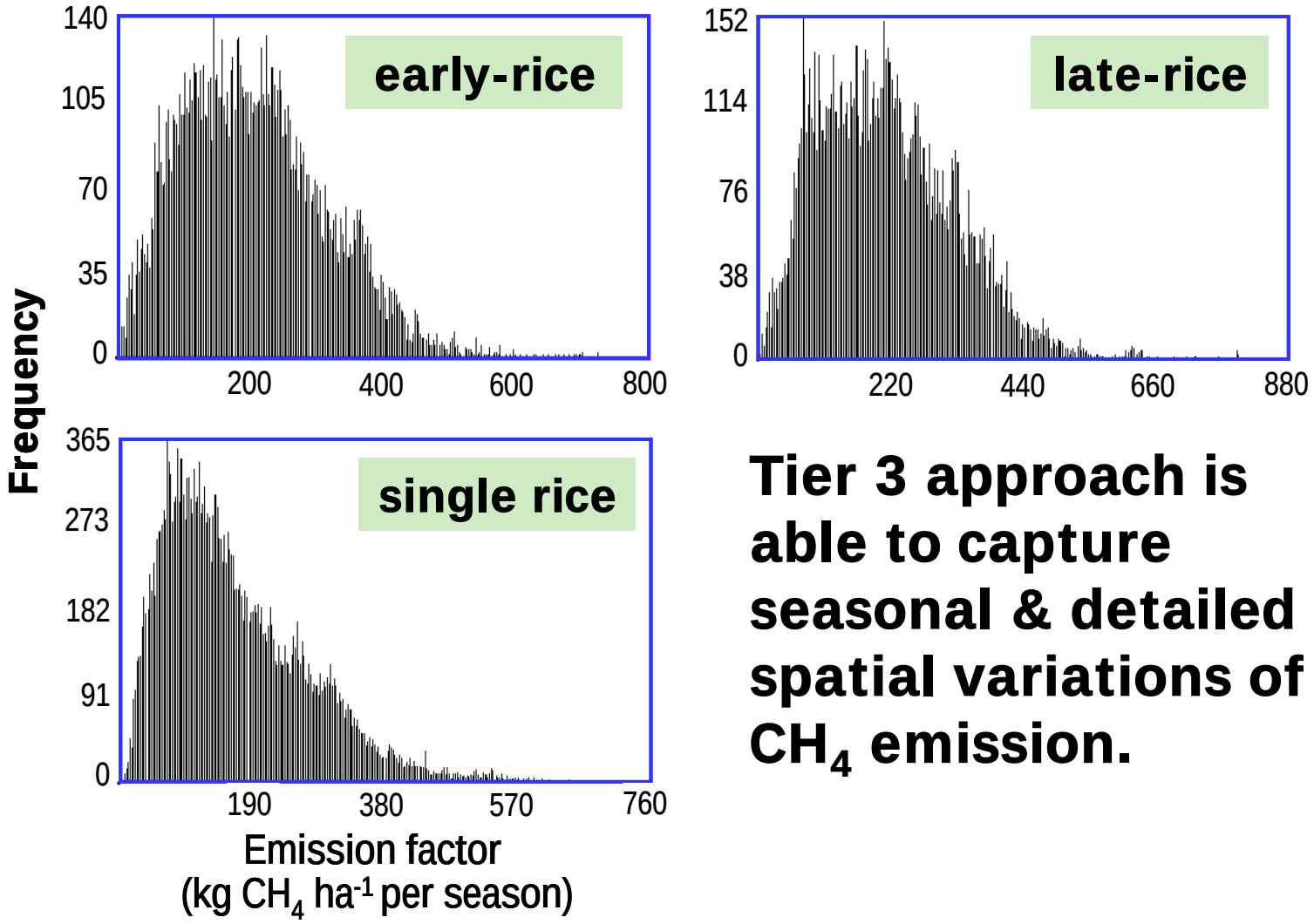


INVENTORY:

Disaggregated at provincial level



Benefit of measurement/model Tier 3



Tier 3 approach is able to capture seasonal & detailed spatial variations of CH_4 emission.

Problems using Tier 3

- **Restriction on activity data (insufficient and imperfect)**

  The types and amounts of organic amendments

  - **Farmyard manure:** farmer survey
  - **Crop residues:** estimated from the yields of preceding crops, harvest index, root:shoot ratio and retention rate of crop residues

  Water management

Problems using Tier 3

- **Upscaling**

  Resolution & data abundance

  High resolution needs abundant and uniform distributed data points

  Low resolution needs less data points, but may result in low confidence in the inventory

Summary

- CH4MOD can reasonably simulate CH_4 emission from rice paddies
- CH_4 emission from Chinese rice paddies in 2000 rice-growing season was estimated to be 6.02 Tg; 49% from the single rice, 27% and 24% from the early and the late rice cultivation.

Summary

- Benefit of Tier 3 is the model's capability of capturing seasonal & detailed spatial variations of CH_4 emission.
- Problems using Tier 3 are the restriction on activity data and the choice of upscaling resolution.


Thank you