Simulation of methane emissions from rice paddies and tropical wetlands in CLM4

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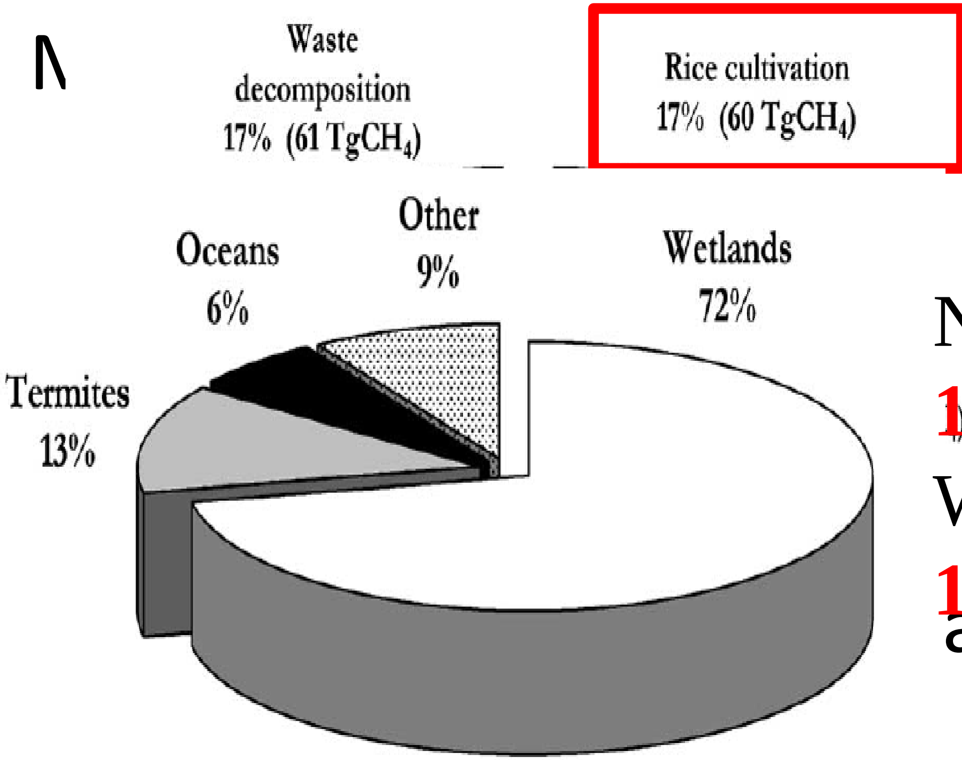
Outline

- Introduction
- Two new features in the methane model
- Model simulations against observations
- Conclusions

Introduction

- Methane emission from rice paddies
- M lands
- ethane budget
- al methane budget



(Wuebbles &Hayhoe 2002)

Total anthropogenic sources of methane are about **358** Tg /year (IPCC' 2007)

Natural sources: **145~260** Tg/yr

Wetlands: **100~231** Tg/yr

http://www.mccullagh.org/db9/vietnam/vietnam-rice-paddy-fields.jpg

Model description (1)

- We used the methane model developed by Riley et al at LBNL.

$$P_{ch4} = HR * f(T) * f(WTP) * f(pH) * f(redox)$$

CLM-CN heterotrophic respiration

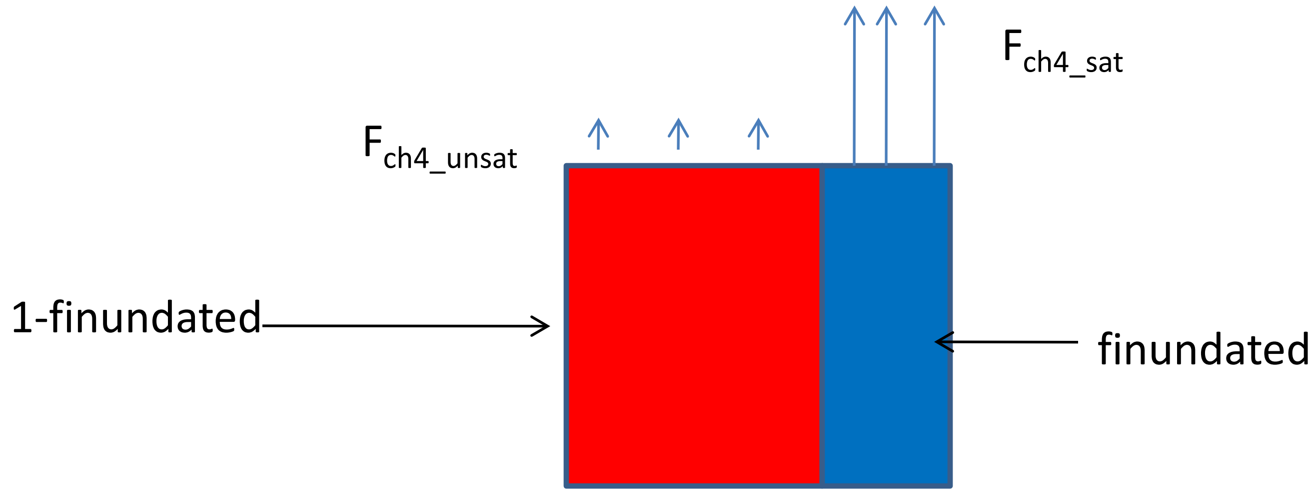
Soil temperature

Water table position

Soil pH

Redox potential

Model description (2)



$$F_{ch4} = \text{finundated} * F_{ch4\_sat} + (1 - \text{finundated}) * F_{ch4\_unsat}$$

Net CH4 flux at each grid cell

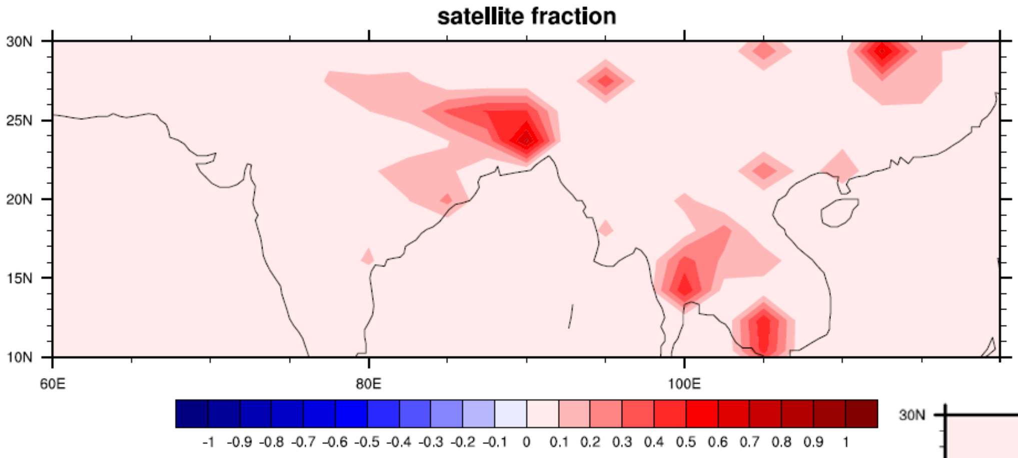
Fractional inundation at each grid cell

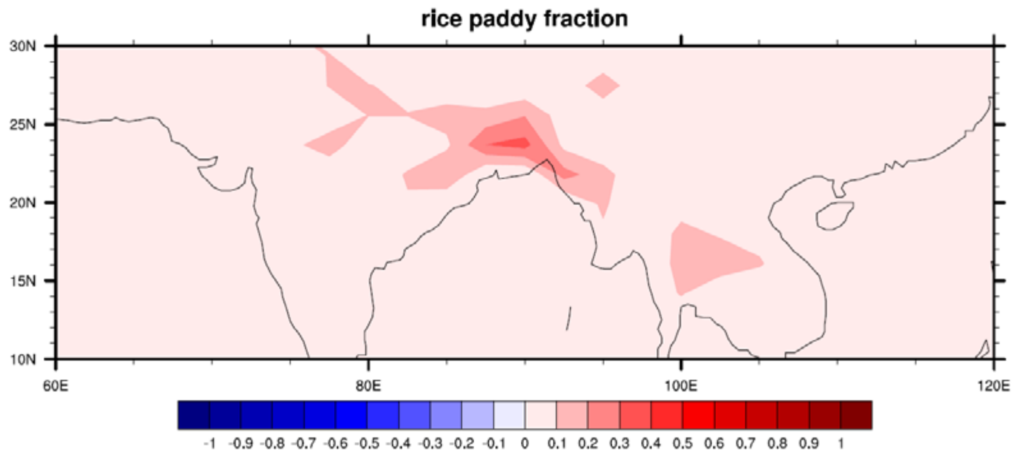
Net CH4 flux from saturated portion

Net CH4 flux from unsaturated portion

Distribution of Rice paddies and wetlands

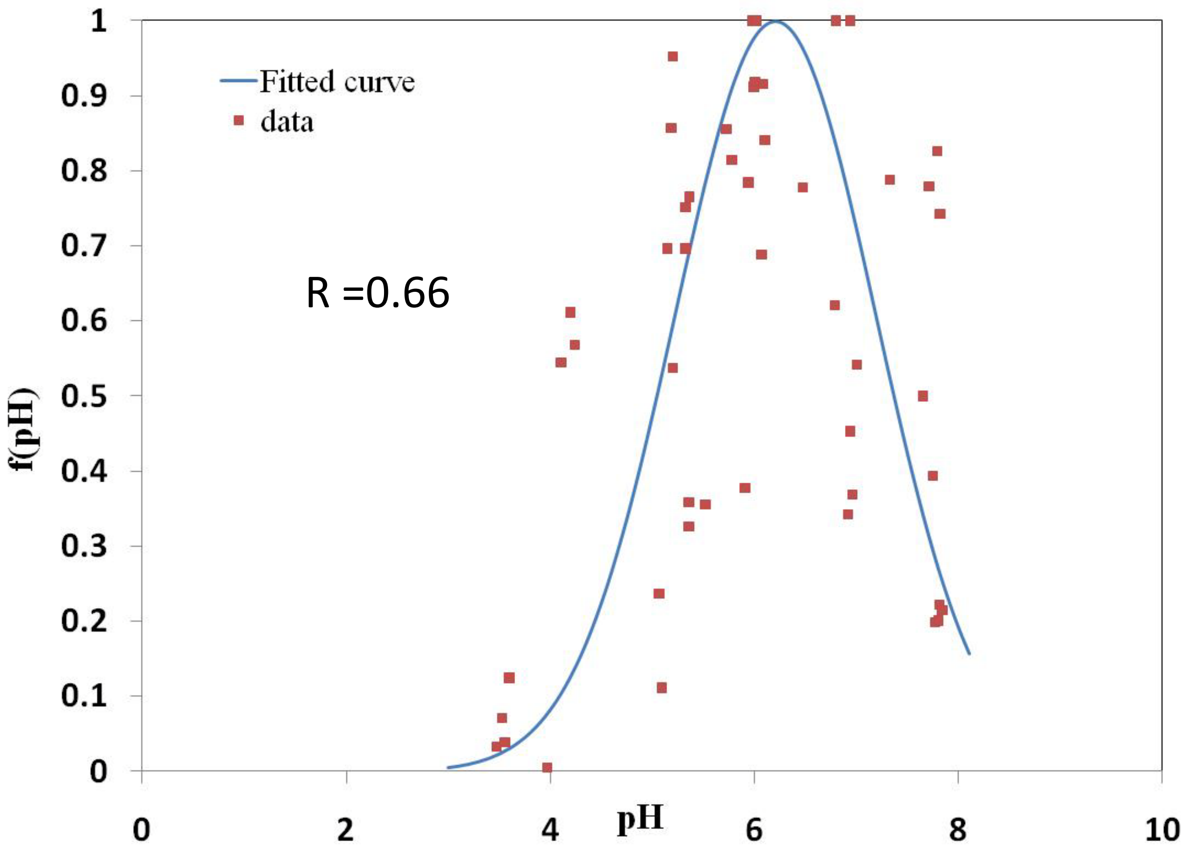
- We forced the model with external fractional inundation and rice paddy fraction in order to remove potential errors associated with CLM hydrology.





(Matthews et al. 1991, Prigent et al. 2007)

pH dependence of methane production



Field and laboratory datasets

Advantage:
Allow for methane production from bogs which often has low pH values

$$f(pH) = 10^{-0.2335*pH^2 + 2.7727*pH - 8.6}$$

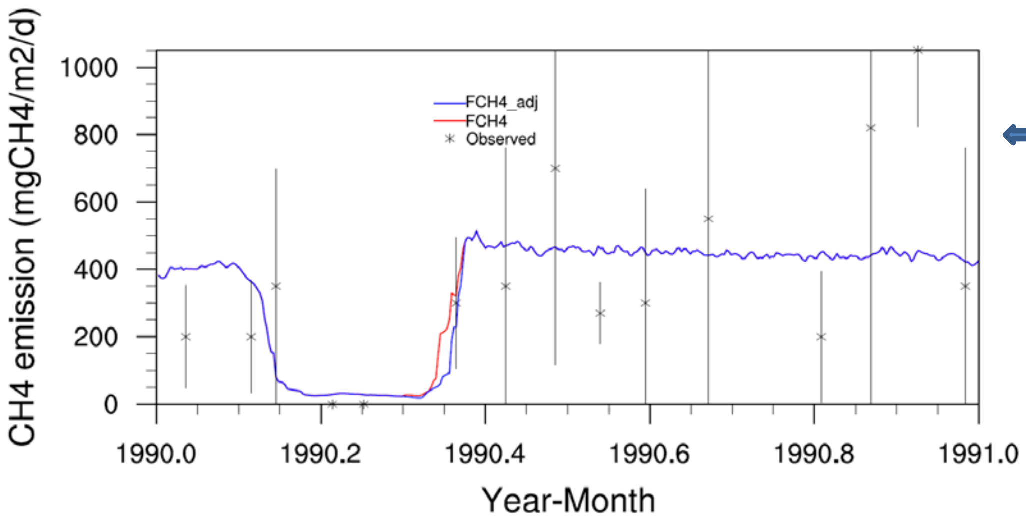
(Data from Dunfield et al. 1993,Soil Biol. Biochem)

Impact of redox potential on methane production

Assumptions:

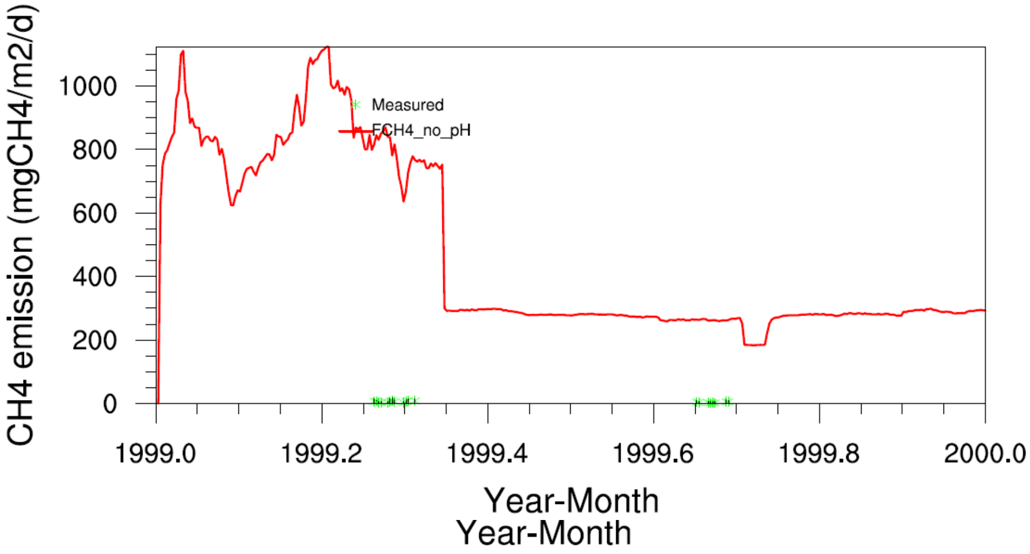
1. Newly inundated land will not produce methane initially, because of the availability of other electron acceptors (O_2, SO_4^{-2}, Fe^{3+}, etc)
2. As the other electron acceptors are consumed, the inundated fraction which will produce methane grows. The fraction with other electron acceptors decays with an e-folding time scale of 30 days. (chosen to match data/understanding)
3. Redox potential will reduce methane production.

Simulations of tropical wetland (1)



Panama
pH =6

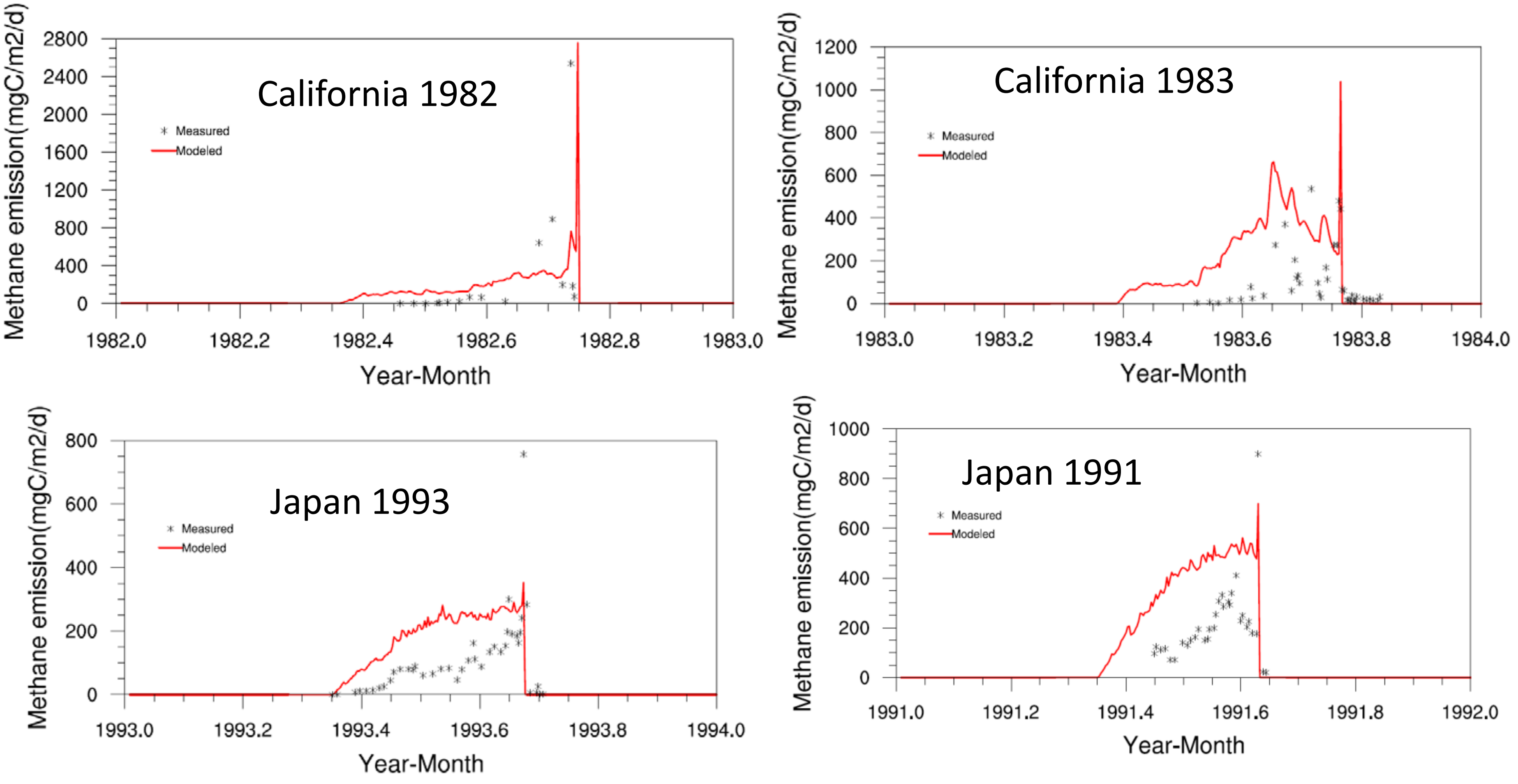
Indonesia
pH =4.0



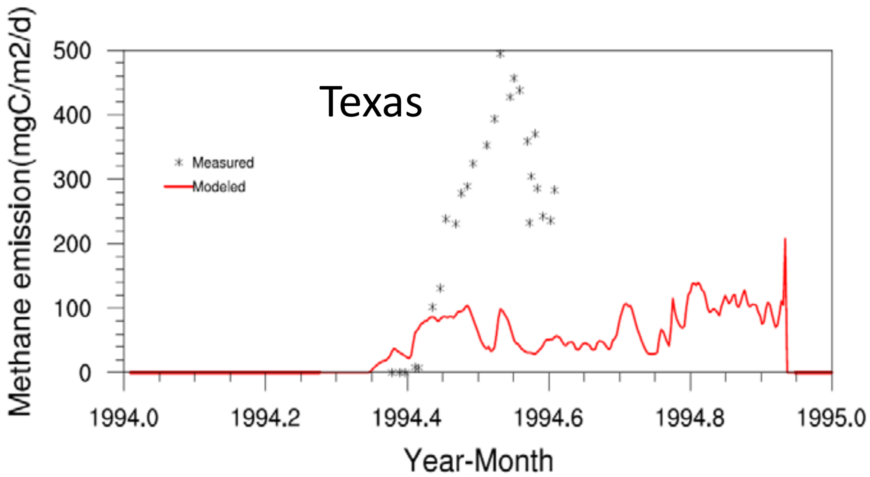
Rice paddy simulation (1)

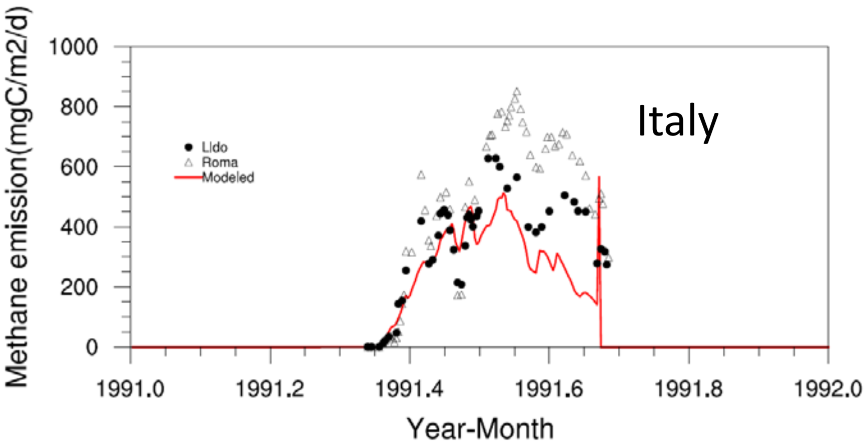
Assumption: 1. Rice paddy fields are fully unsaturated before flooding and transplanting and are continuously flooded until harvest

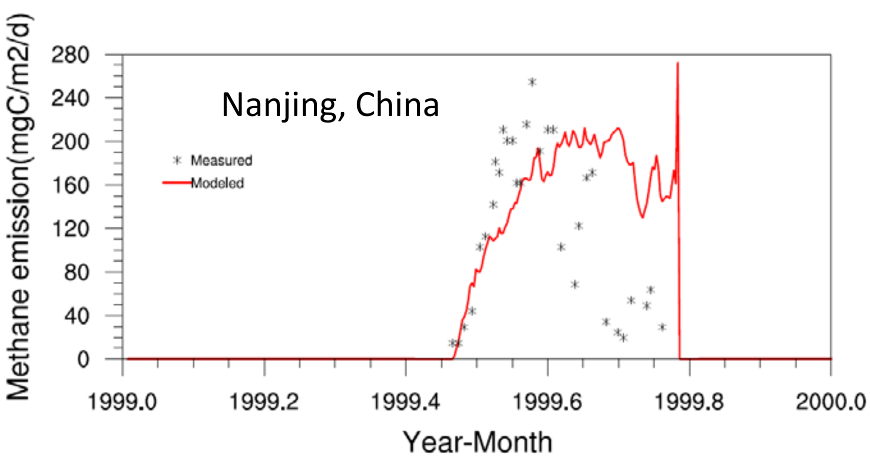
2. Under balanced condition, soil C will be degraded to 50% CO_2 and 50% CH_4

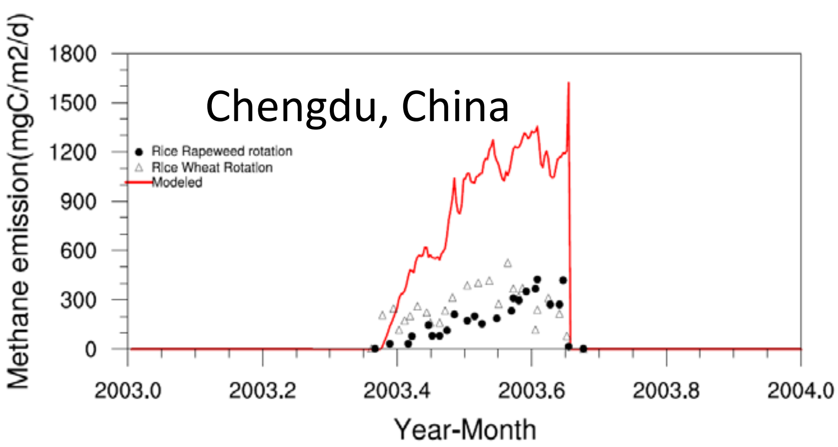


Rice paddy simulations (2)







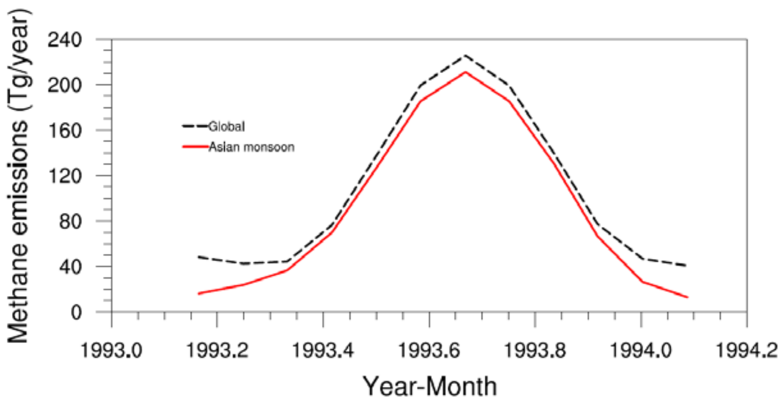


Global simulation-Rice paddy

- Global average: 106 Tg/year (Others:23 Tg/year -120 Tg/year)

-- assume continuous flooding (no drainage during growing seasons)

--overestimate methane emissions from Asian rice paddies



Global simulation-Wetlands

	Our model	Other models
Global	133	100-231
Tropical (20N-30S)	82	66- 88+

Units: Tg /year

Conclusions

- Two new features (pH and redox potential) have been added into the methane model.
- Preliminary results suggest that the improved methane model does a reasonable job in simulating methane emissions from tropical wetlands and rice paddy fields

Impact of Redox potential on methane production (2)

$$F_{ch4} = \text{finundated\_adj} * F_{ch4\_sat} + (1 - \text{finundated\_adj}) * F_{ch4\_unsat}$$

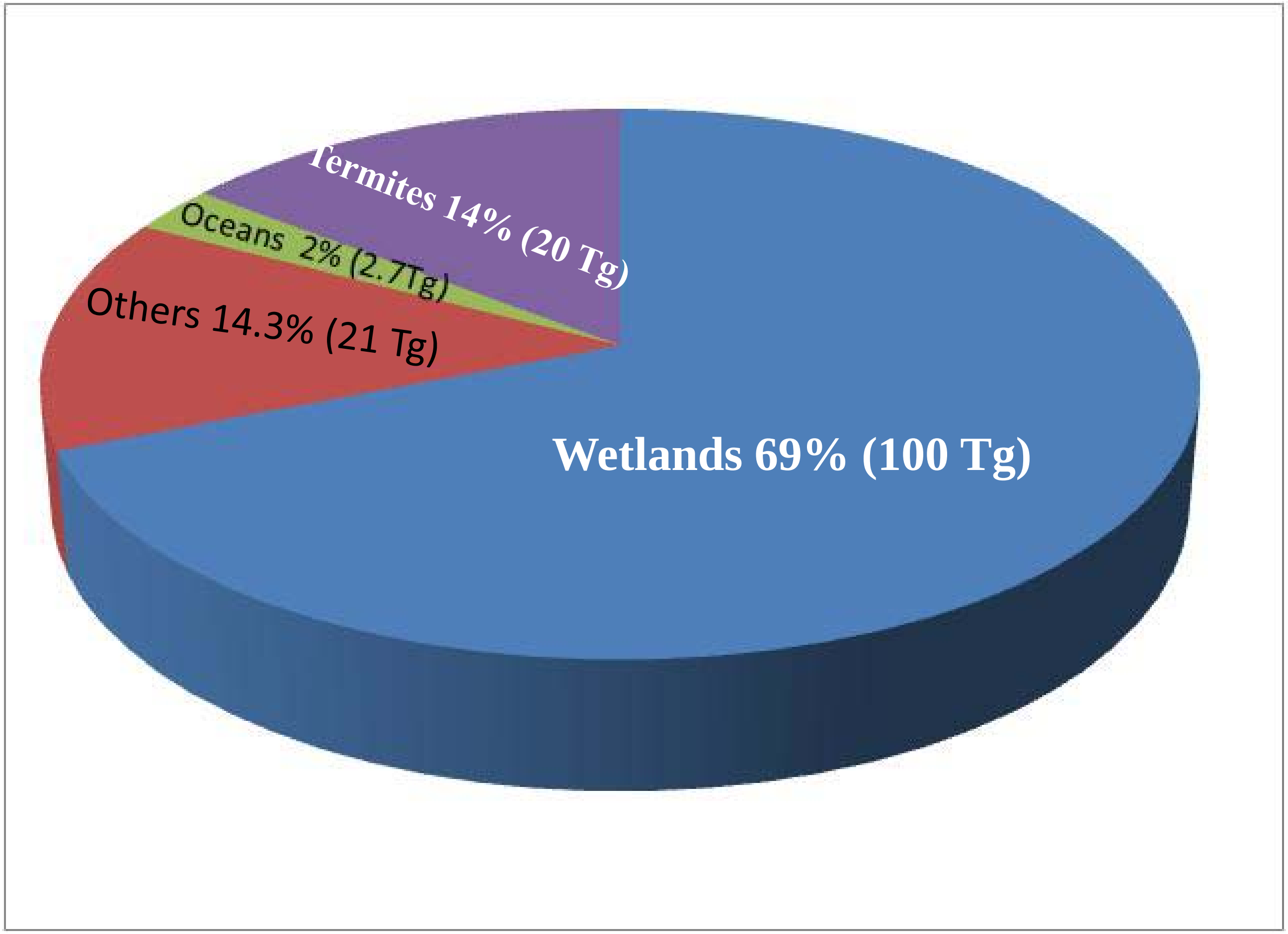
$$\text{finundated\_adj} = \text{finundated} - \text{fredox}$$

fredox(t) = finundated(t) – finundated(t-1) -newly inundated land
+ fredox(t-1)*(1- Δt/tau) -30 days decay

$$\frac{d(fredox)}{dt} = \frac{d(finundated)}{dt} - \frac{fredox(t-1)}{tau}$$

fredox is the fraction of gridcell with other species (such as O_2, SO_4^{-2}, Fe^{+3}) to consume finundated is the original fractional inundation of gridcell, finundated_adj is the adjusted fractional inundation, tau is the delay time (30 days) for other species, t is the current time step and t-1 is the previous time step

Similarly, the redox potential can also delay the methane production in soil layers


Termites 14% (20 Tg)
Oceans 2% (2.7Tg)
Others 14.3% (21 Tg)
Wetlands 69% (100 Tg)