Understanding the influence of rice paddies on atmospheric CH_4

Bill Salas and Thuy Le Toan

K&C Initiative, 4th Science Advisory Panel Meeting, May 2003, Tokyo

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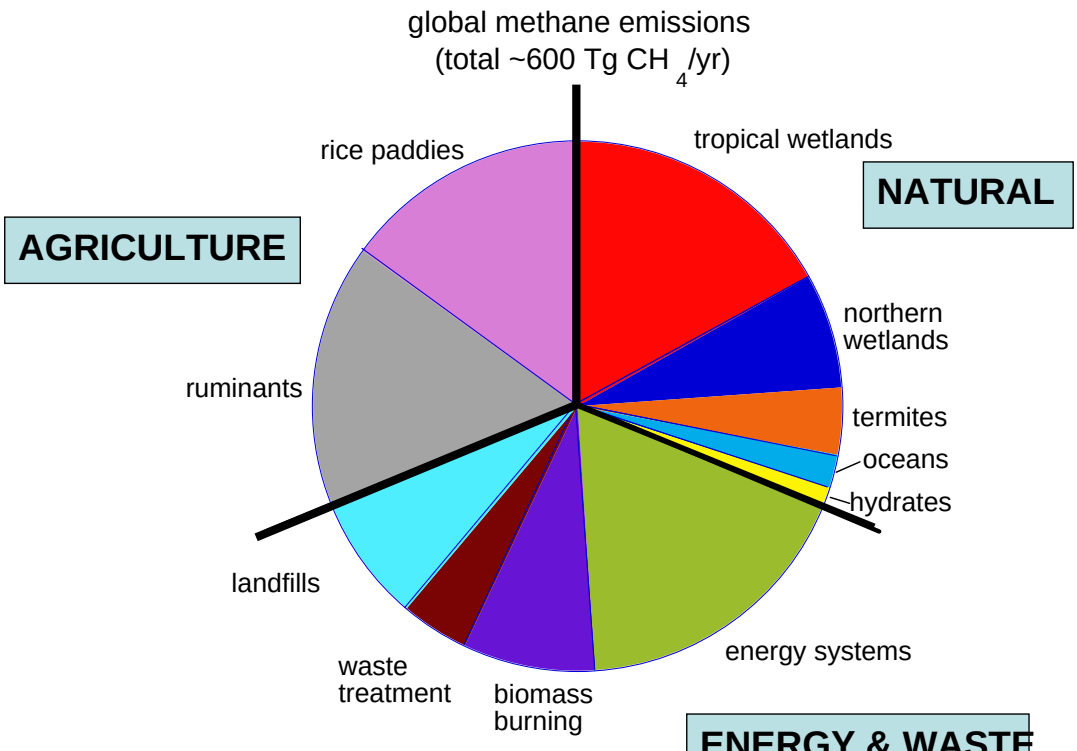
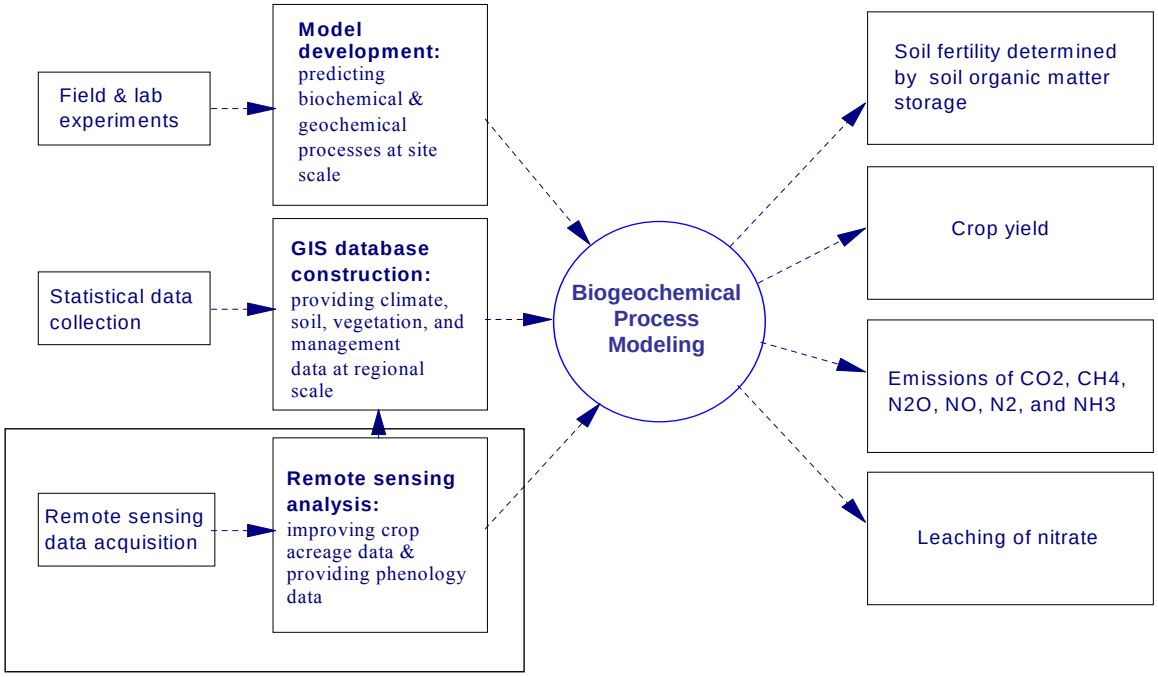
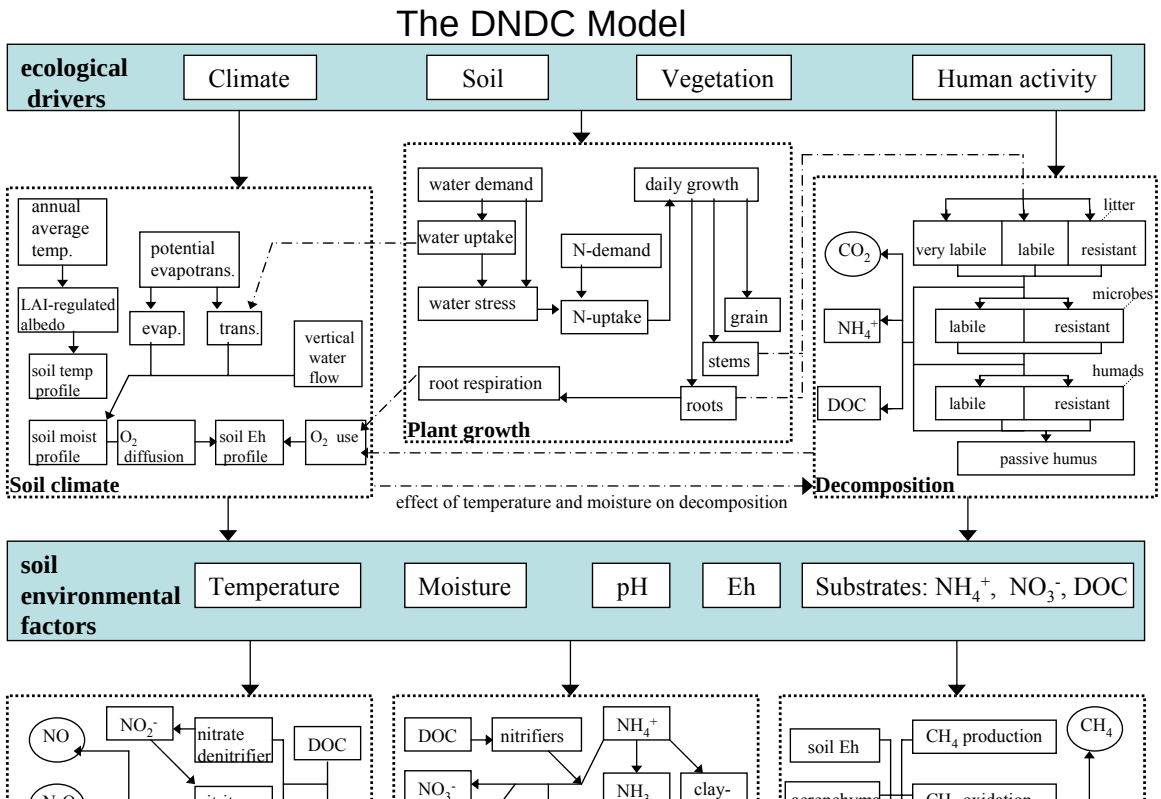
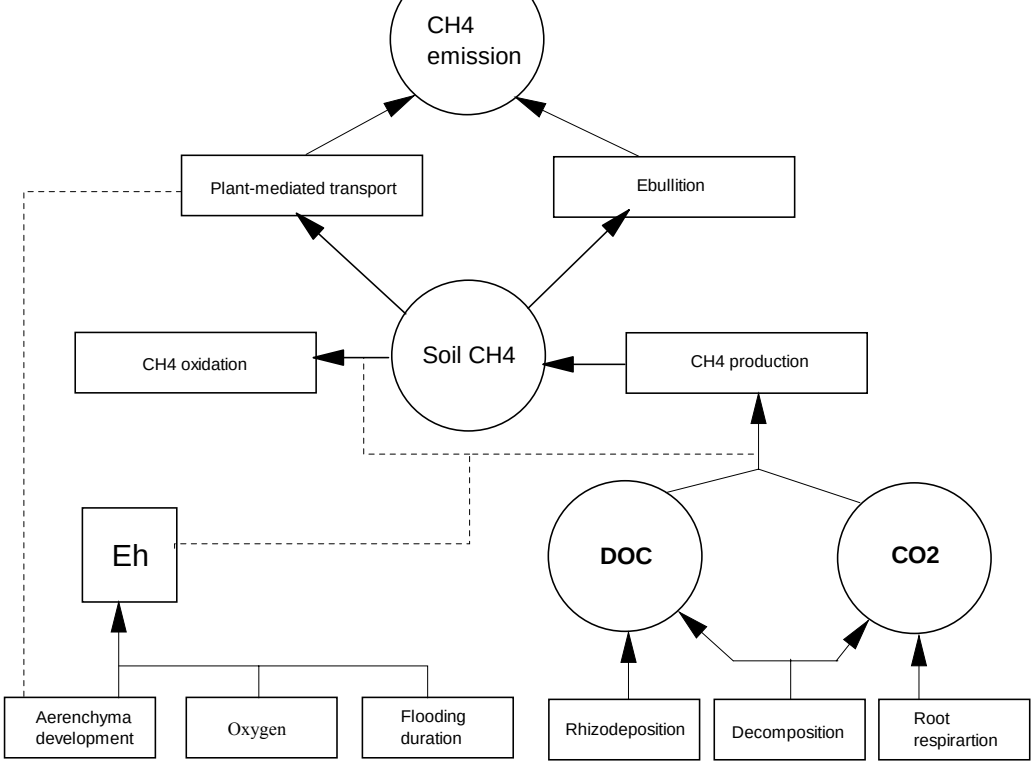



Field & lab experiments
Model development: predicting biochemical & geochemical processes at site scale
Statistical data collection
GIS database construction: providing climate, soil, vegetation, and management data at regional scale
Remote sensing data acquisition
Remote sensing analysis: improving crop acreage data & providing phenology data
Biogeochemical Process Modeling
Soil fertility determined by soil organic matter storage
Crop yield
Emissions of CO2, CH4, N2O, NO, N2, and NH3
Leaching of nitrate


The DNDC Model
ecological drivers
Climate
Soil
Vegetation
Human activity
annual average temp.
potential evapotrans.
LAI-regulated albedo
evap.
trans.
vertical water flow
soil temp profile
soil moist profile
O2 diffusion
soil Eh profile
O2 use
Soil climate
water demand
daily growth
water uptake
N-demand
water stress
N-uptake
grain
stems
root respiration
roots
Plant growth
litter
very labile
labile
resistant
CO2
microbes
NH4+
labile
resistant
humads
DOC
labile
resistant
passive humus
Decomposition
effect of temperature and moisture on decomposition
soil environmental factors
Temperature
Moisture
pH
Eh
Substrates: NH4+, NO3-, DOC
NO
NO2-
nitrate denitrifier
DOC
DOC
nitrifiers
NH4+
NO3-
NH3
clay-
soil Eh
CH4 production
CH4



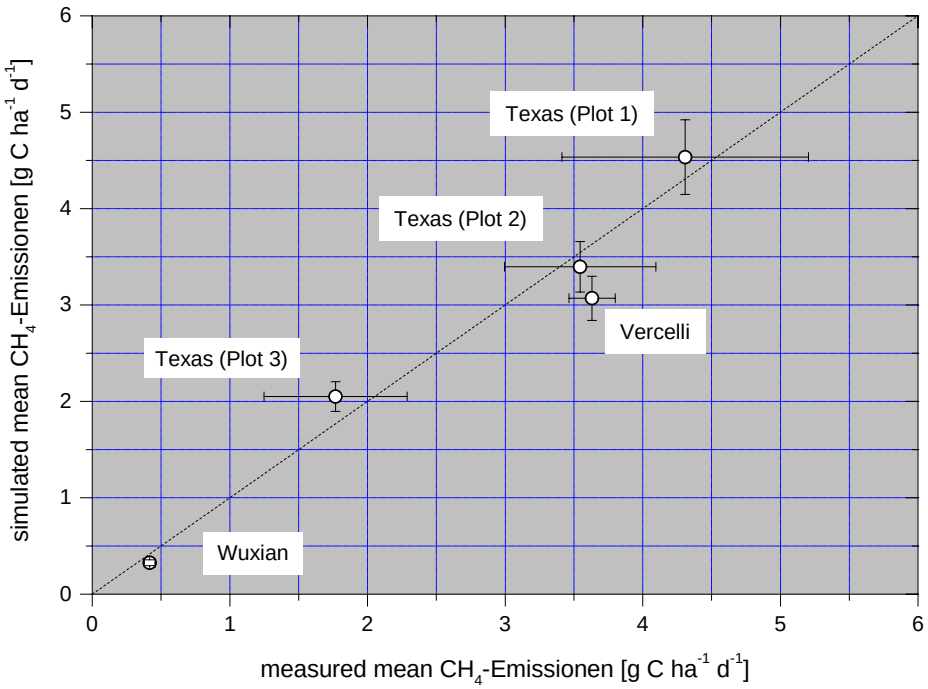
Factors Affecting CH_4 Biogeochemistry in DNDC

Production: $P_{(CH4)} = f(DOC+CO_2, O_2, T, t, clay, pH);$

Oxidation: $O_{(CH4)} = f(CH_4, O_2);$

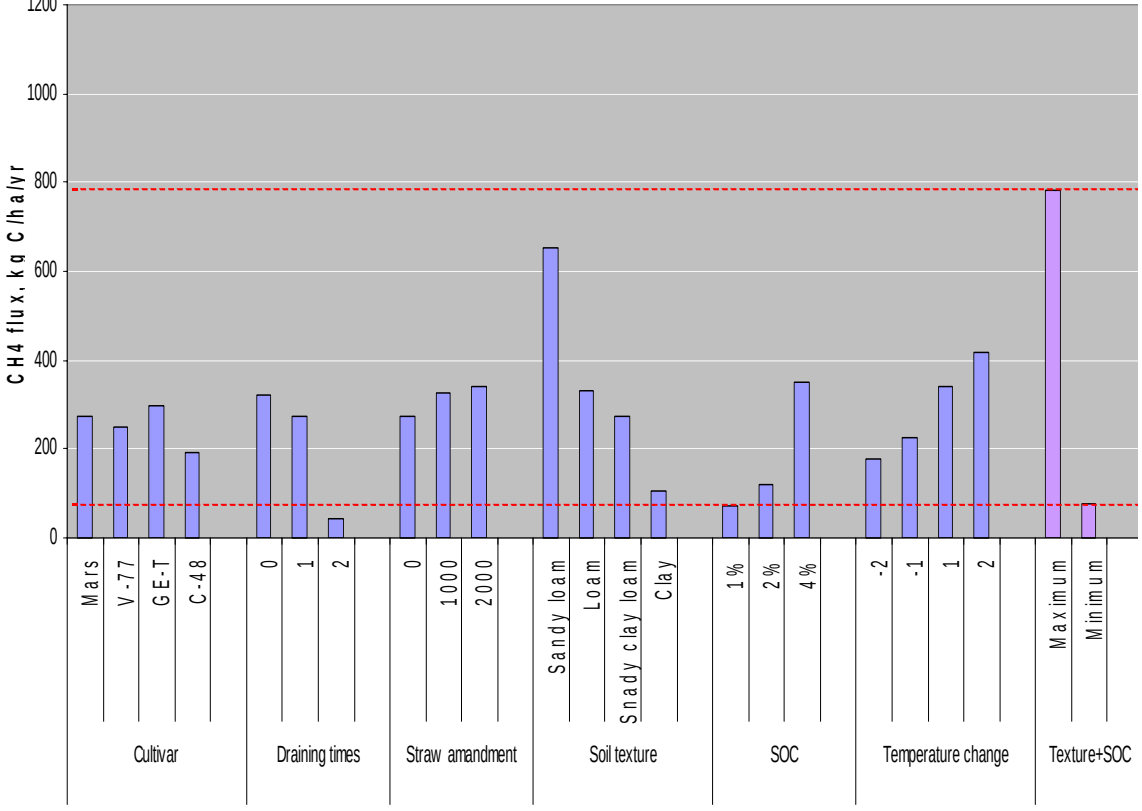
Plant transport: $T_{(CH4)} = f(CH_4, LAI);$

Ebullition: $E_{(CH4)} = f(CH_4, T, clay, root\ mass).$



Regional DNDC Rice Validation

Map of validation sites: 1 Mikasa, 2 Tsukuba, 3 Fengqiu, 4 Nanjing, 5 Jurong, 6 Suzhou, 7 Chongqing, 8 Yingtan, 9 Changsha, 10 Guangzhou, 11 Chiang Mai, 12 Surin,

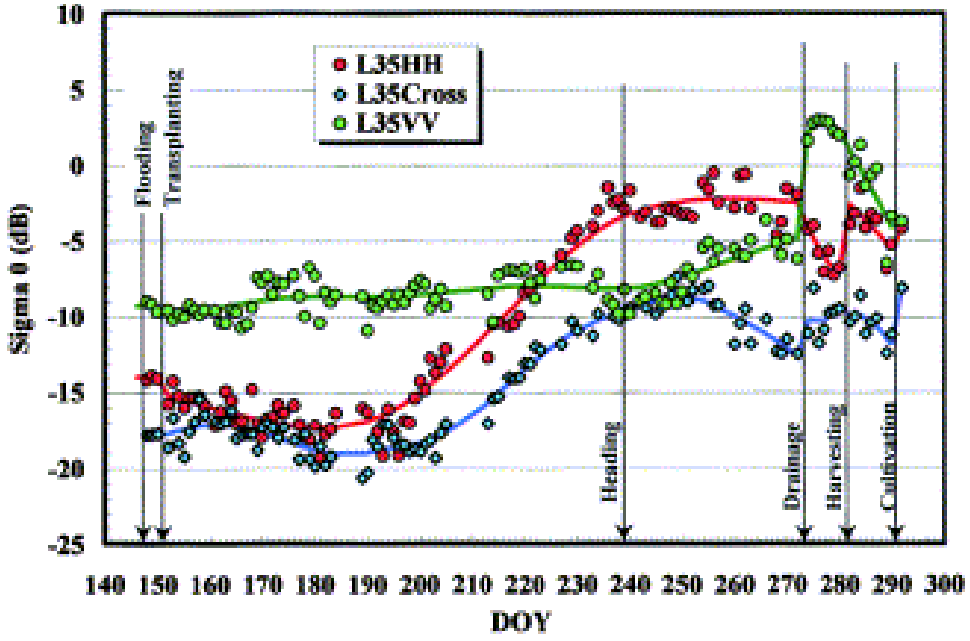


Cultivation Cycle and SAR Response

High specular (forward) scattering, very low backscatter.

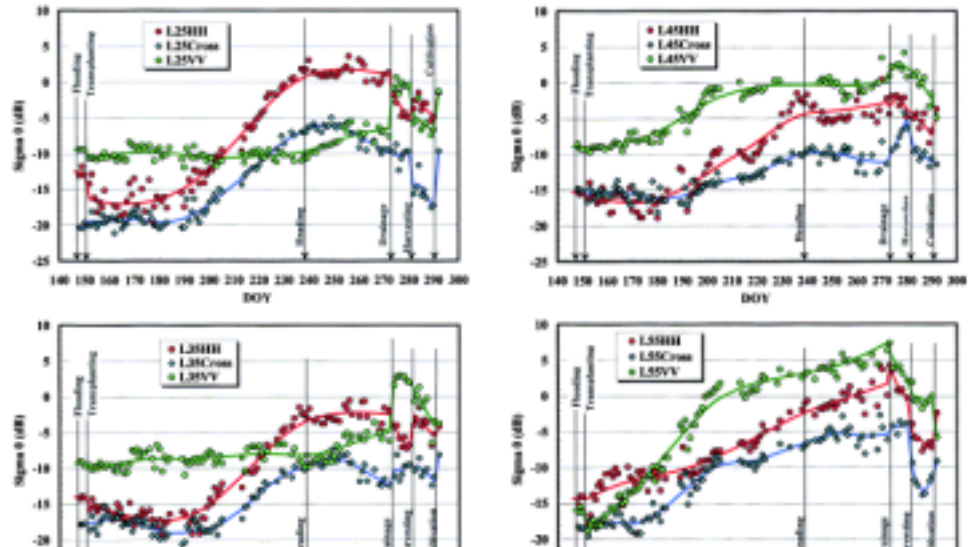
Moderate specular (forward) scattering, moderate backscatter.

Low specular (forward) scattering, higher backscatter.

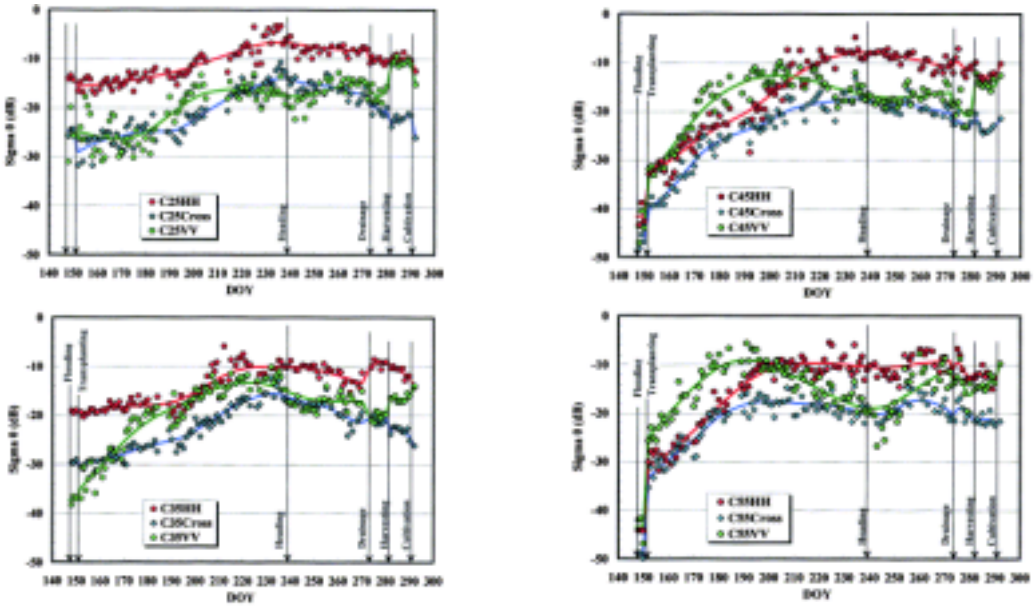


Source: Inoue et al. 2002

Temporal Changes in L-band σ Polarization and Incidence Angle Effects



Polarization and Incidence Angle Effects



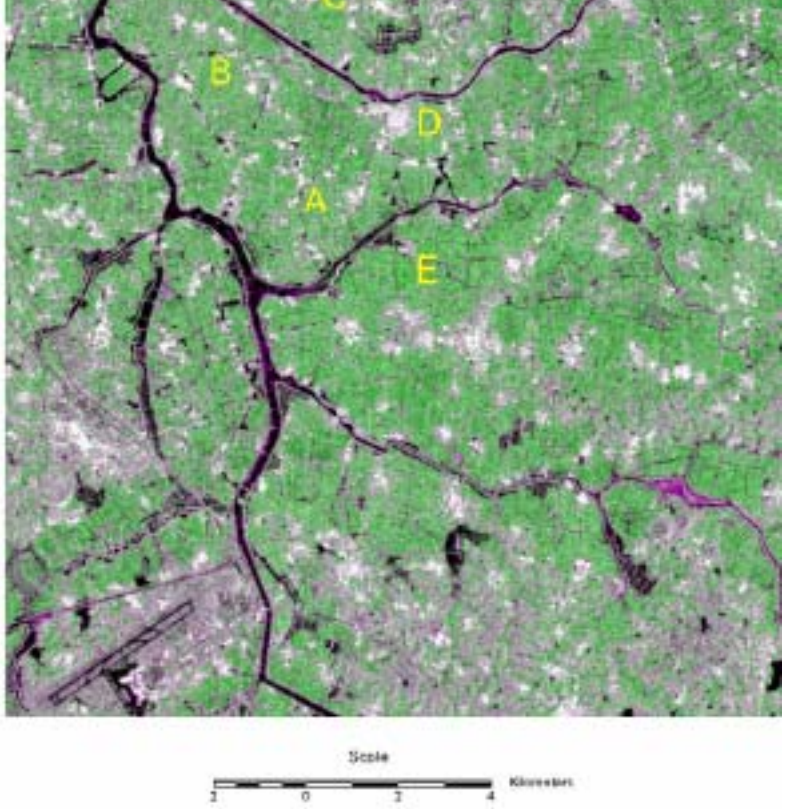
Source: Inoue et al. 2002

K&C Irrigated Rice Products

- *"Operational"*:
  - ***Paddy Extent***. Coverage to include all of Asia (China, India, SE Asia) which includes 90% of total rice area globally.
  - ***Crop cycles.*** Map single-, double-, triple-rice and rice/upland double cropping.
  - ***Flood Duration***. Period of inundation
- "Research":
  - ***Biomass/LAI development.*** Track biomass/LAI development.
  - ***Mid-season drainage.*** Quantify the presence of mid-season drainage.

Standard Beam
Radarsat Imagery:
Jiangning County, China.

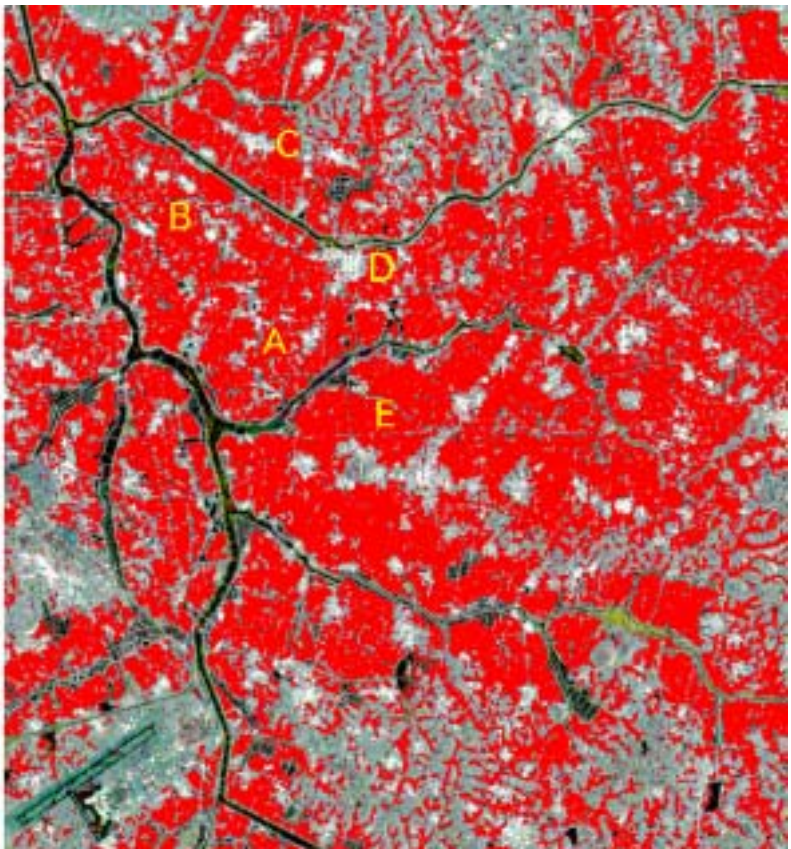
Note: letters indicate
Locations of field sites.

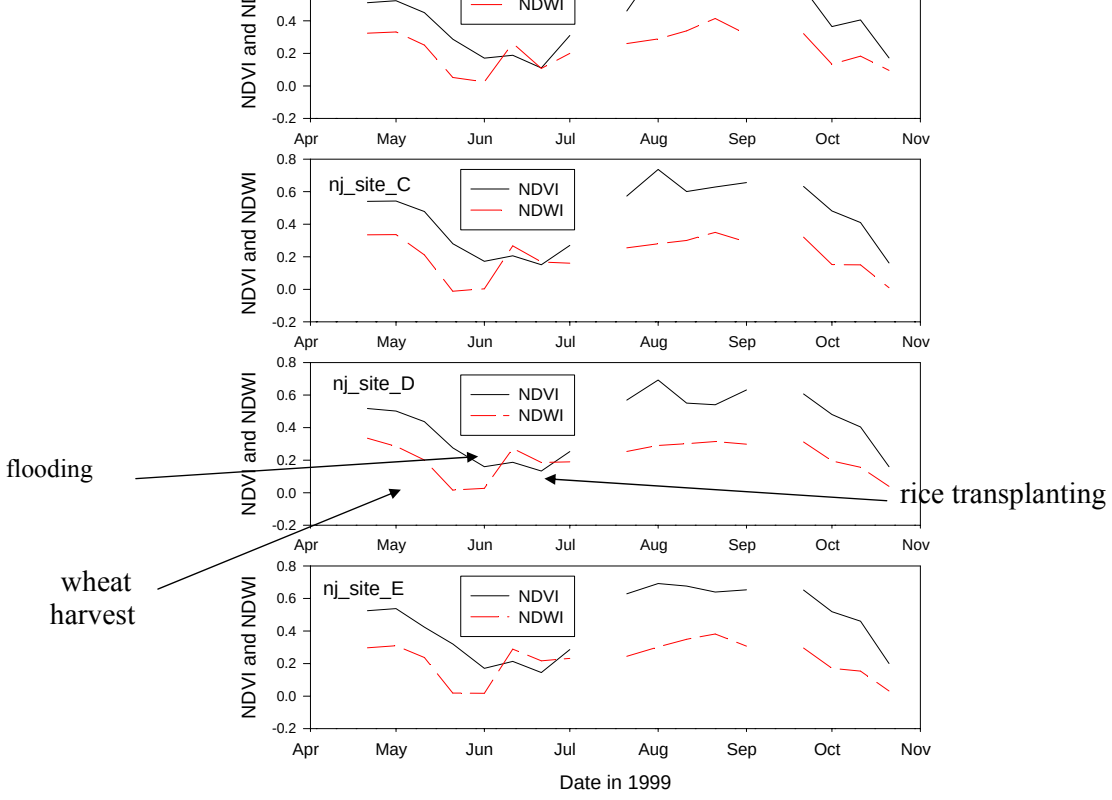


Automated classification
of rice paddy extent using
a >3db shift.

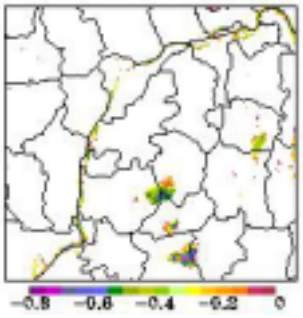
Note: letters indicate
Locations of field sites.

Accuracy > 93%
Kappa> 0.89

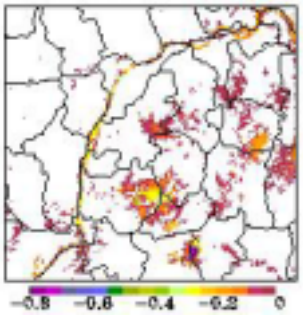




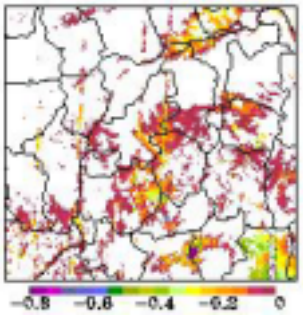
(a) NDVI – NDWI in April 21-30, 1999



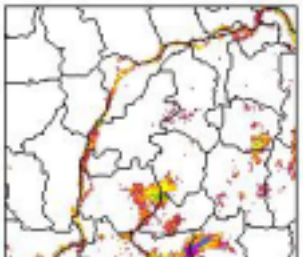
(b) NDVI – NDWI in June 11-20, 1999



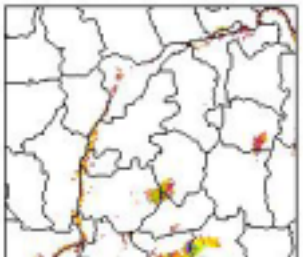
© NDVI – NDWI in June 21-30, 1999



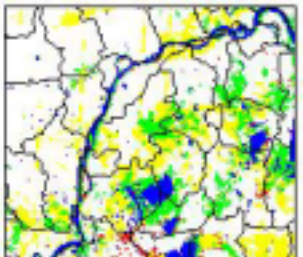
(d) NDVI – NDWI in July 1-10, 1999



(e) NDVI – NDWI in August 1-10, 1999



(f) A thematic map for the timing of flooding & rice transplanting

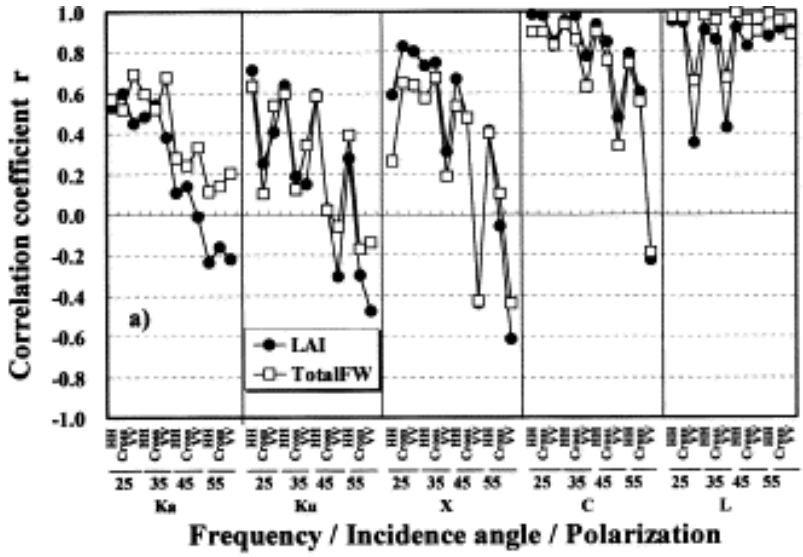


Green – 6/11-20

Yellow – 6/21-30

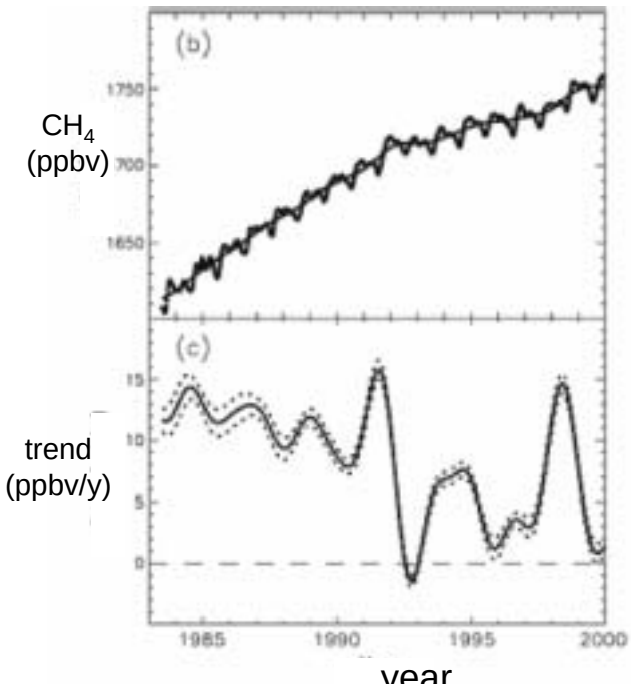
Red – 7/1-10

Plant Fresh Weight



Source: Inoue et al. 2002

Atmospheric methane increase has slowed and become more variable.



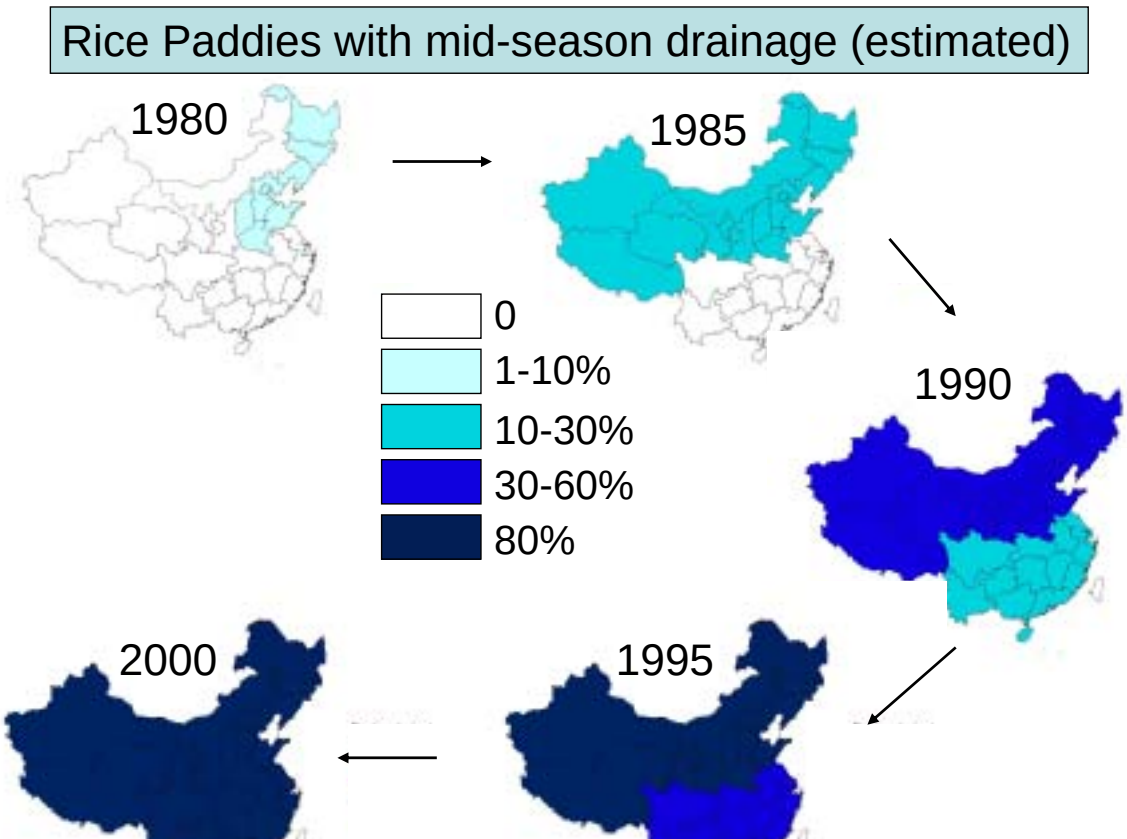
Globally averaged CH_4 (monthly varying) and deseasonalized CH_4 (smooth line) abundance plotted for 1983 to 1999 (Dlugokenkcy et al. 2001).

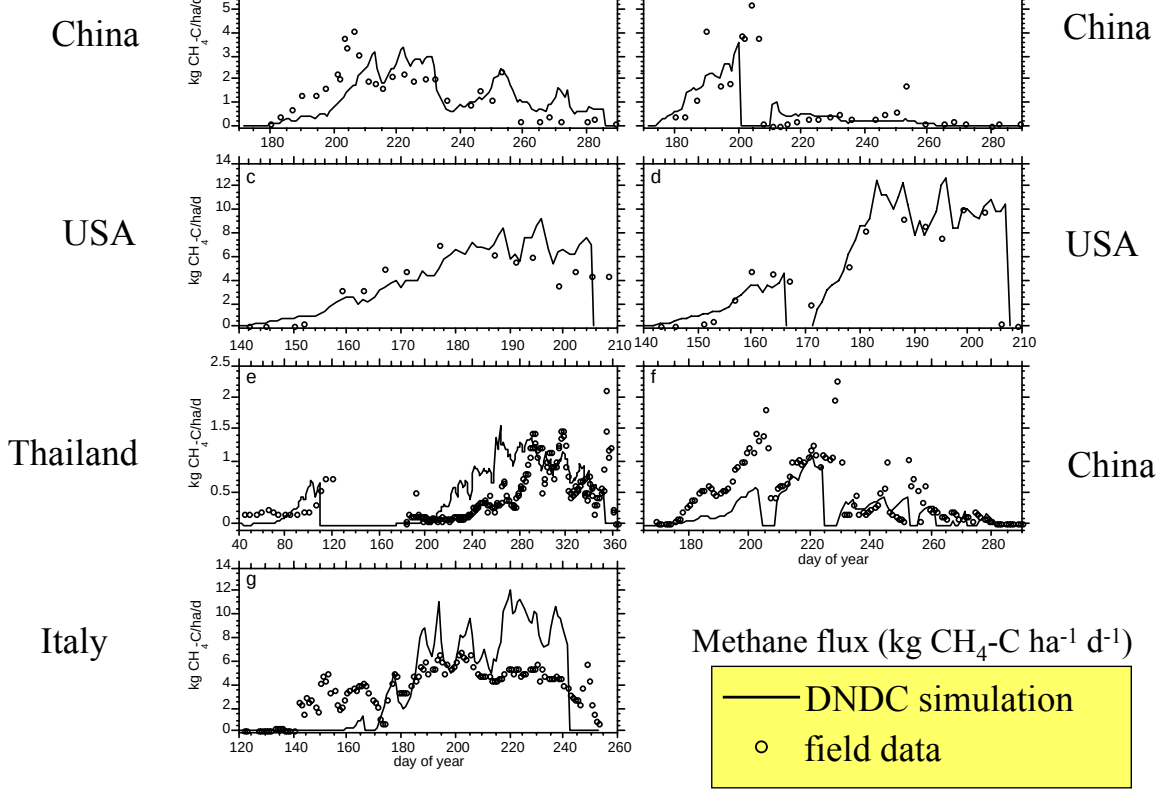
Instantaneous annual growth rate (ppbv/y) in global atmospheric CH_4 abundance from 1983 through 1999 calculated as the derivative of the deseasonalized trend curve above. Dotted lines are $\pm 1\sigma$. (Dlugokenkcy et al. 2001).

- China has ~20% of the world's rice cropland.
- China produces about 30% of the world's rice.
- Almost all rice in China is produced in flooded paddies.

- Water scarcity in the north led to implementation of mid-season draining/drying in the early 1980s.
- Mid-season draining/drying has spread throughout much of China.
- Mid-season draining/drying reduces methane emissions.

- **What has been the impact on the atmosphere?**
  - → DNDC biogeochemistry model
  - → improved maps of rice distribution
  - → rough estimate of changes in water management





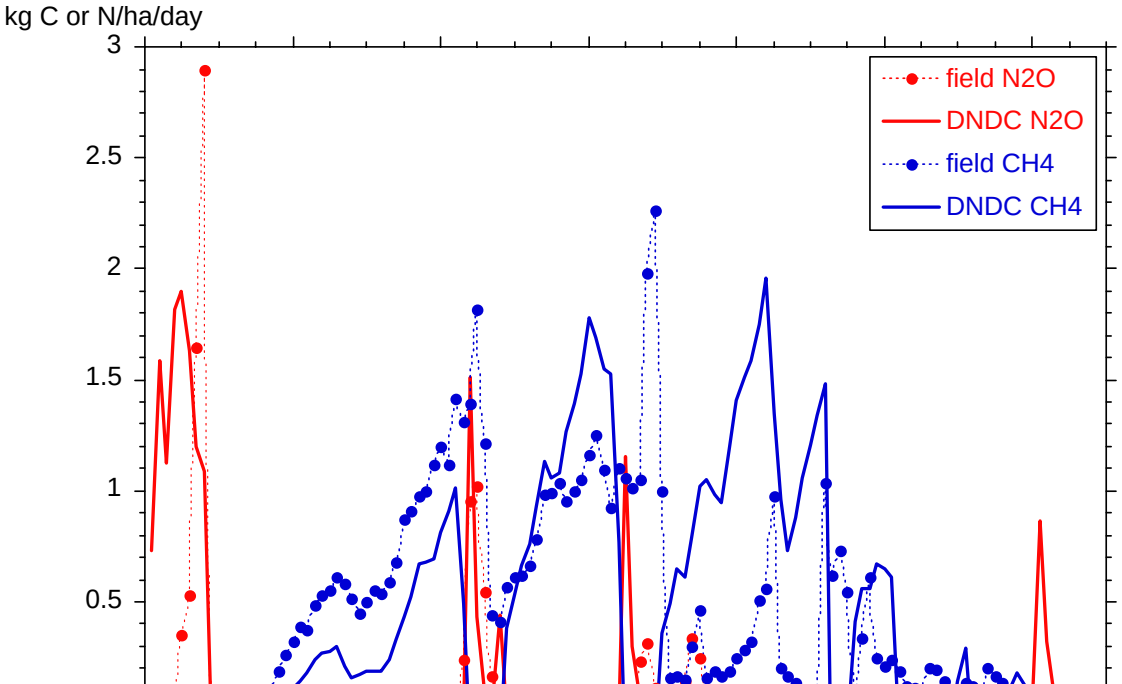
Methane flux (kg CH_4-C ha^{-1} d^{-1})

DNDC simulation

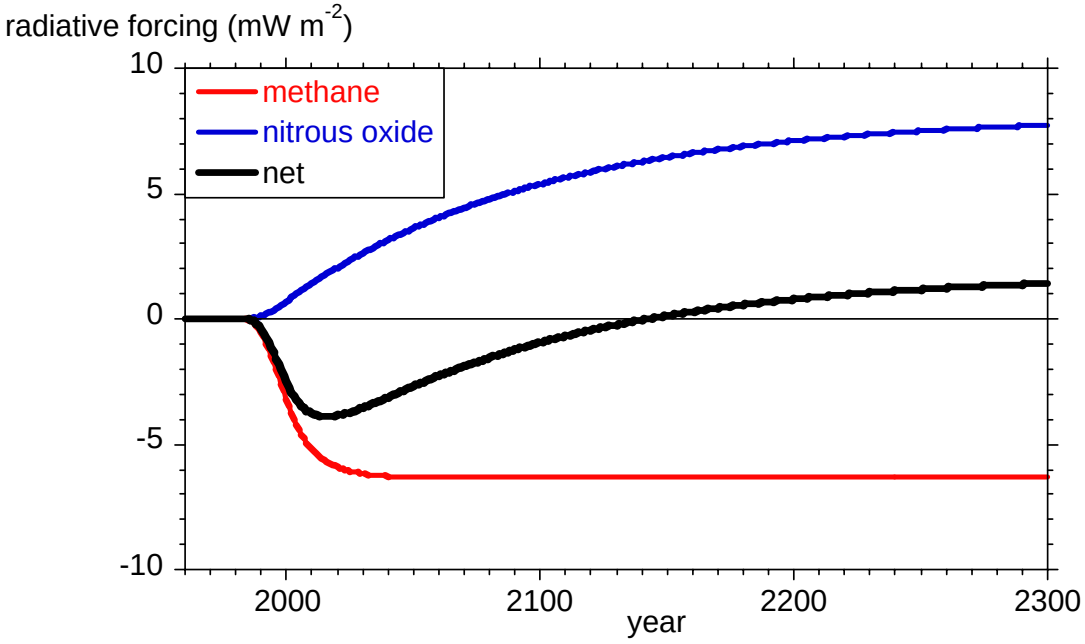
field data

Li et al. (2002) *Geophys. Res. Lett.*

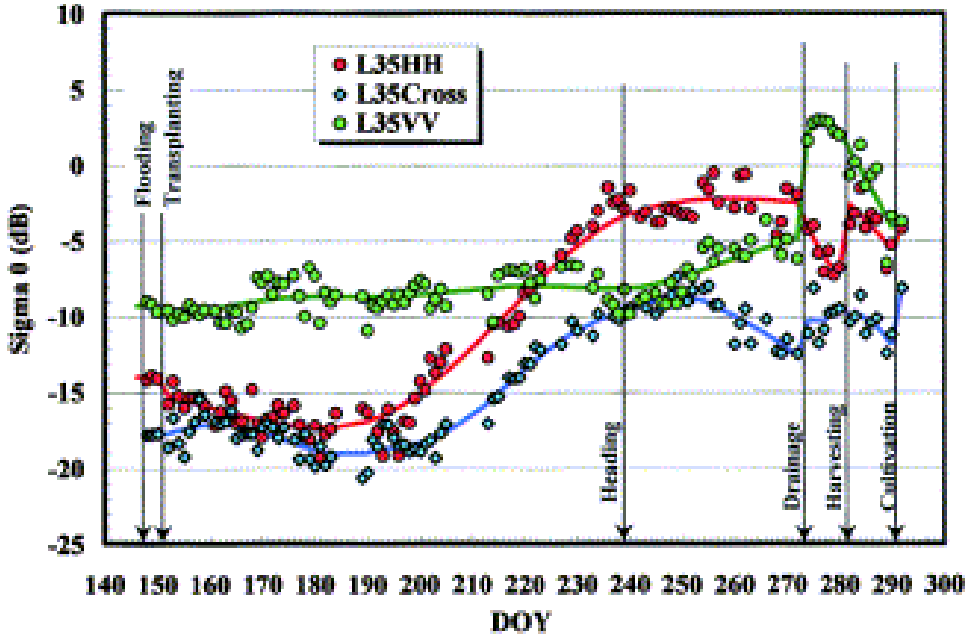
Observed and modeled CH_4 and N_2O fluxes from paddy with mid-season drainings, Jiangsu Province, China, 1997 (field data from Zheng et al. 1999)



- perturbed only by change in China rice paddy fluxes.
- eventually achieves new equilibrium.
- net global radiative forcing is dynamic.

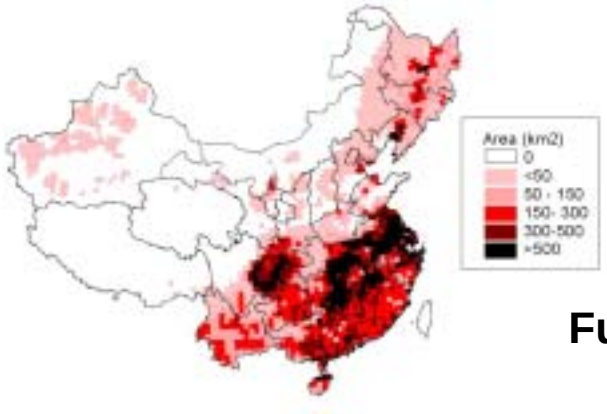


Temporal Changes in L-band Sigma 0



Conclusion

- Triple cropping systems growth period can be <80 days, may not have 2 Scansar acquisitions…
- Short duration of intermittent draining 10-14 days (will likely miss it).
- Coverage maps for scansar acquisition plan does not include areas of rice in China. Are ScanSAR regions set?



Funding…