N fertilizer placements and greenhouse gas emissions from continuously flooded rice systems

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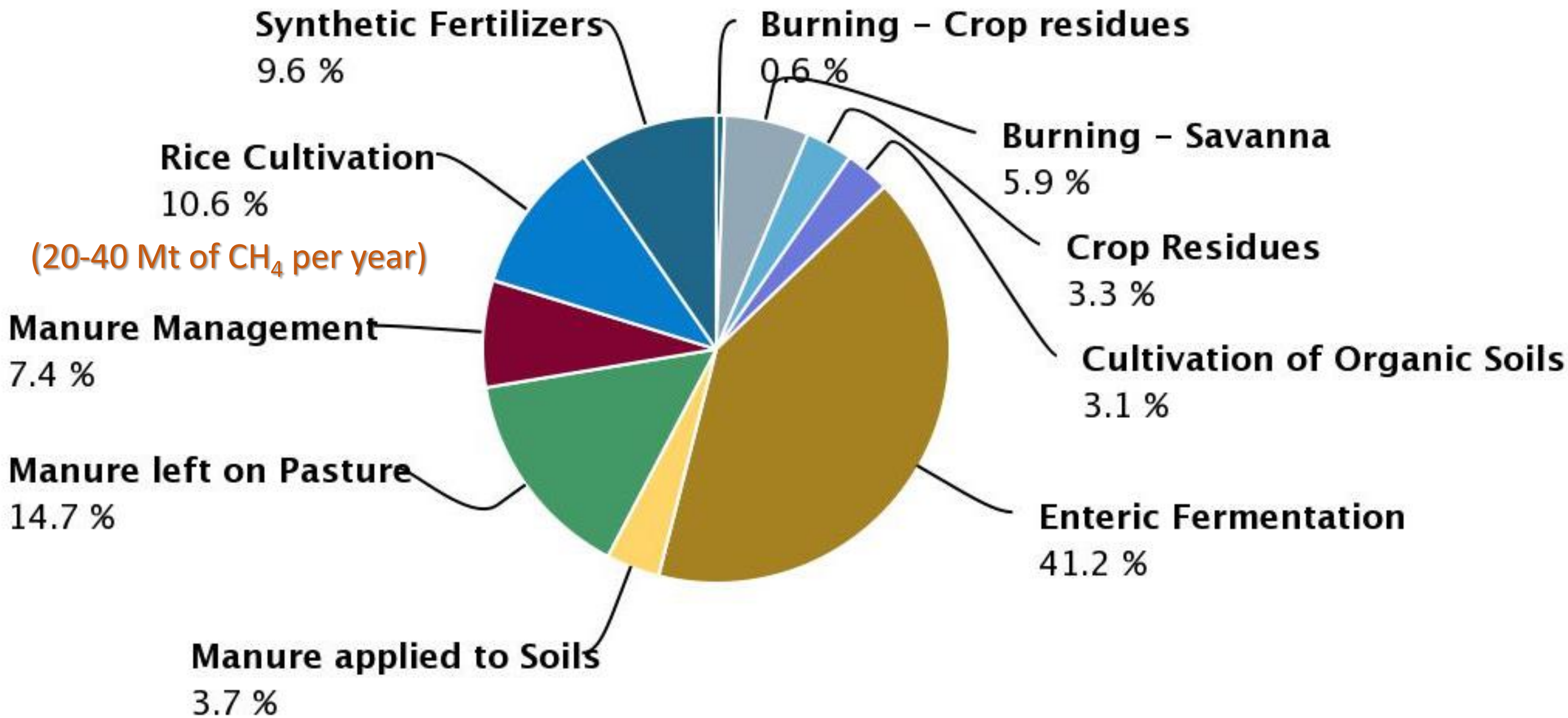
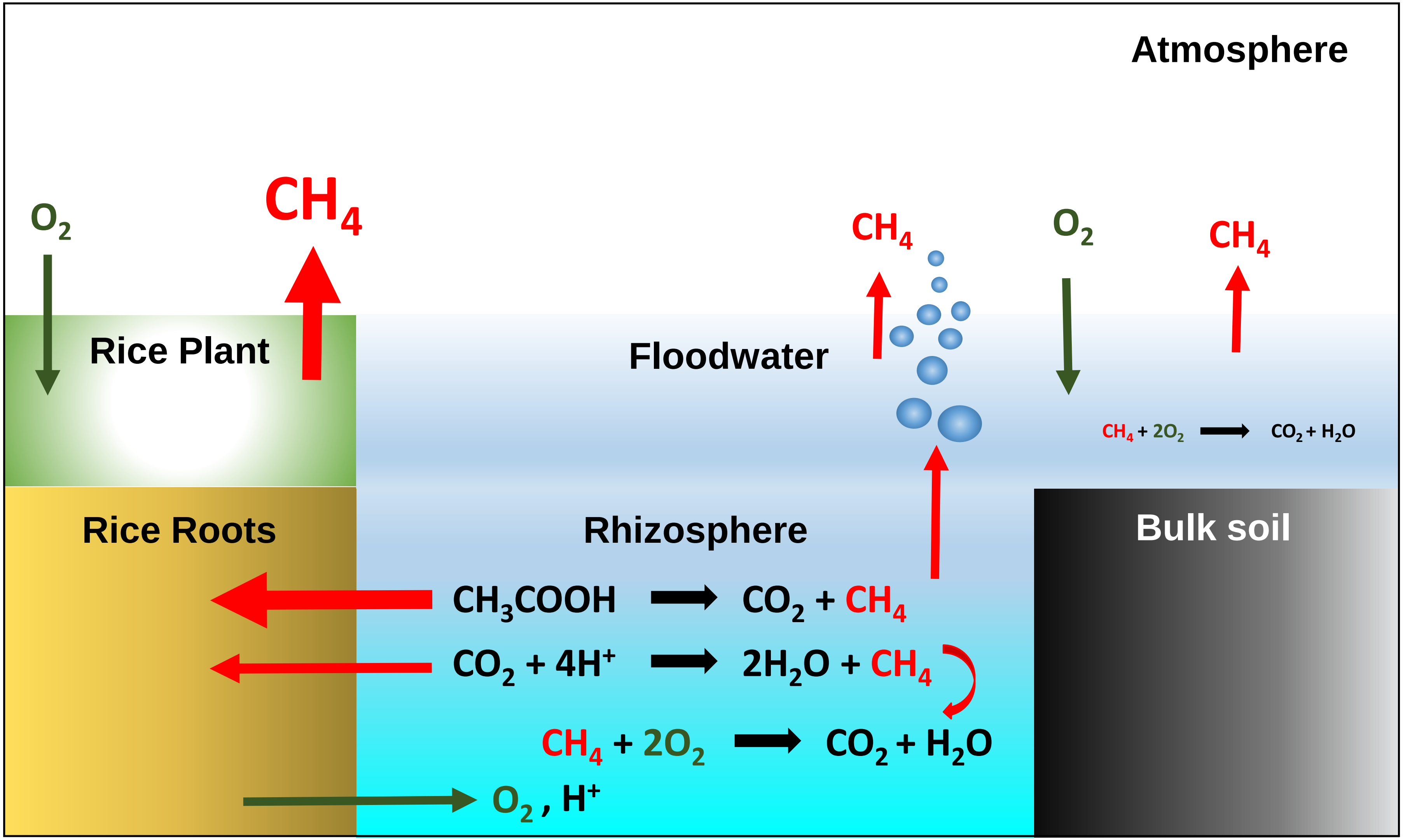
Emissions of CH_4 and N_2O produced from agricultural activities (1961-2011)



Source: FAOSTAT

Processes causing emissions of CH_4 from flooded rice fields



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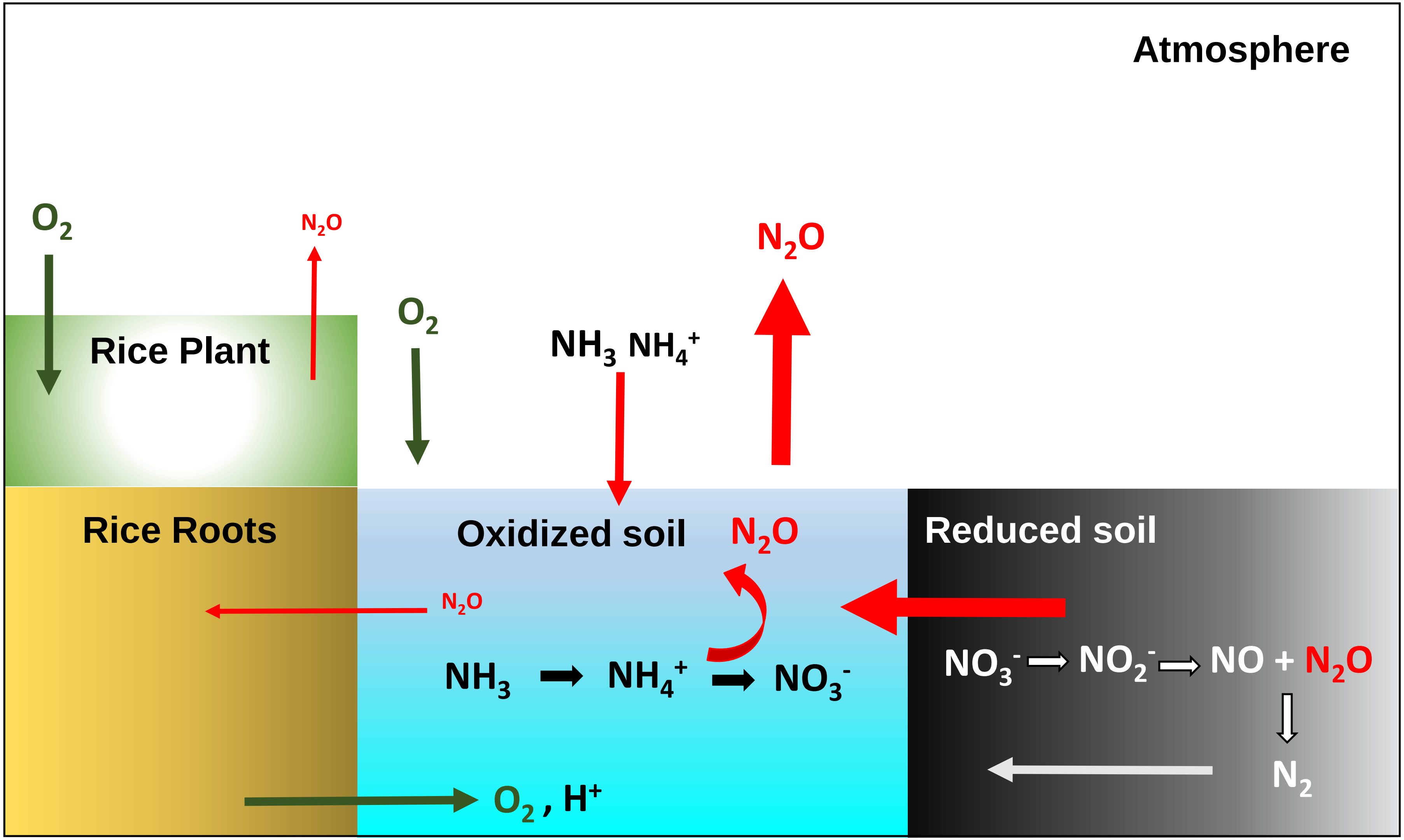
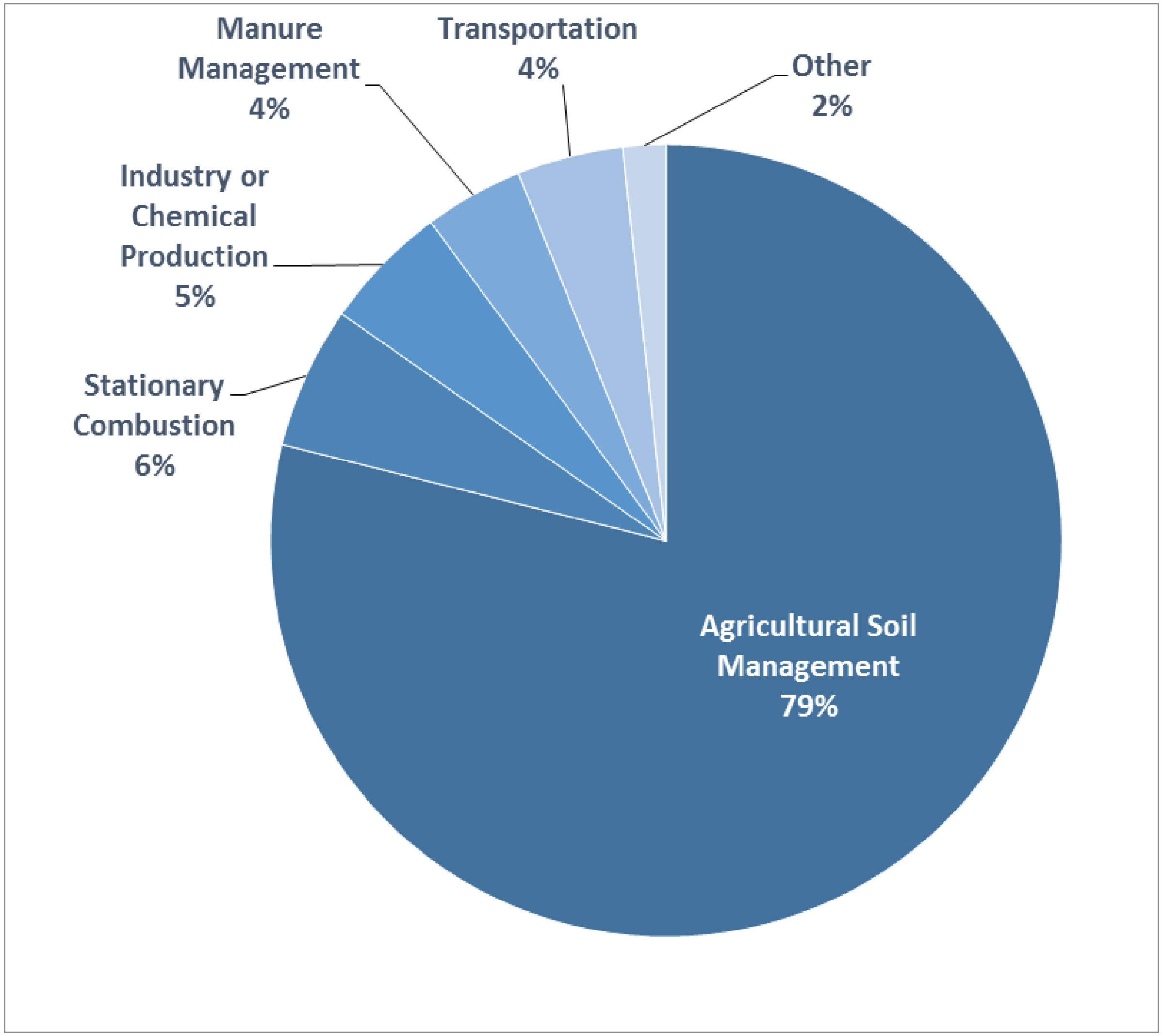
Processes causing emissions of N_2O from flooded rice fields



US Nitrous oxide emissions by source (1990-2014)



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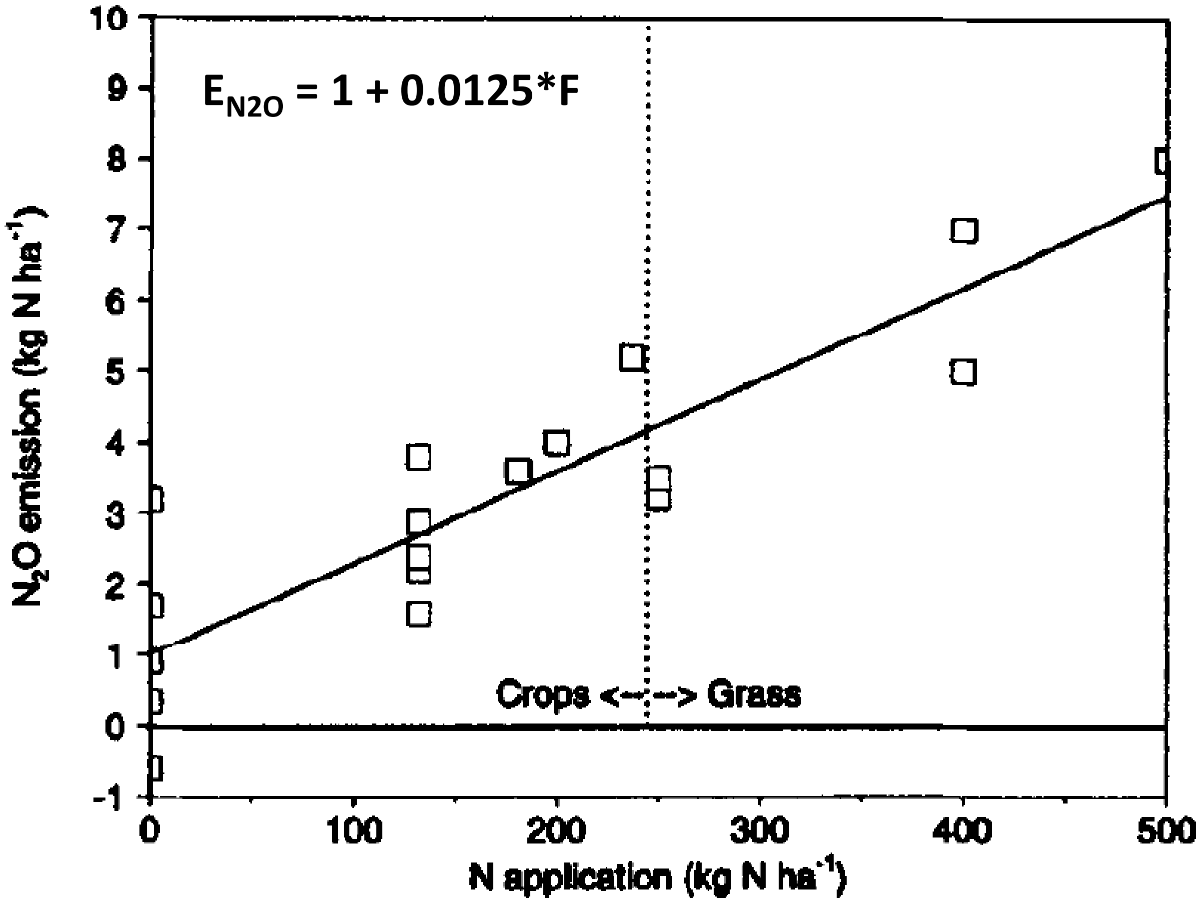
Current default N_2O emission factor for direct emissions



0.21 to 0.40% fertilizer-induced N_2O emission

Source: Bouwman 1996. Nutrient Cyc. Agroeco.52, 165-170.

Management practices for reducing GHG emissions

1. **Water management**
   - Alternate wetting & drying
2. **Rice selections**
   - Hybrids vs conventional
3. **Placement of N fertilizer**
   - Subsurface application
4. **Forms of N**
   - Ammonium sulfate
   - Urease inhibitor
5. **Time of N application**
   - Multiple application
6. **Amount of fertilizer N**
   - Suboptimal rates
   - Optimal rates

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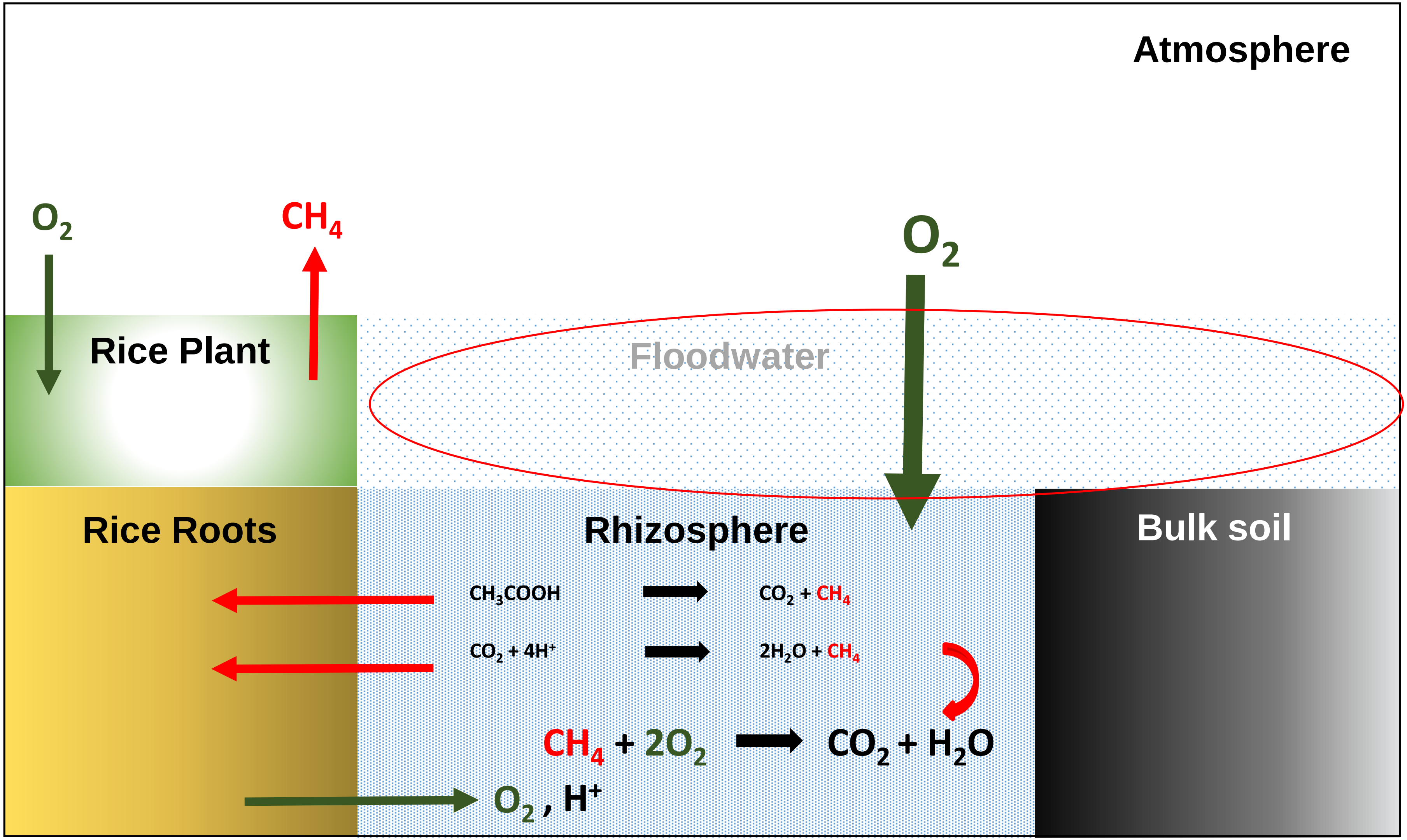
Mitigating CH_4 emissions in flooded rice fields



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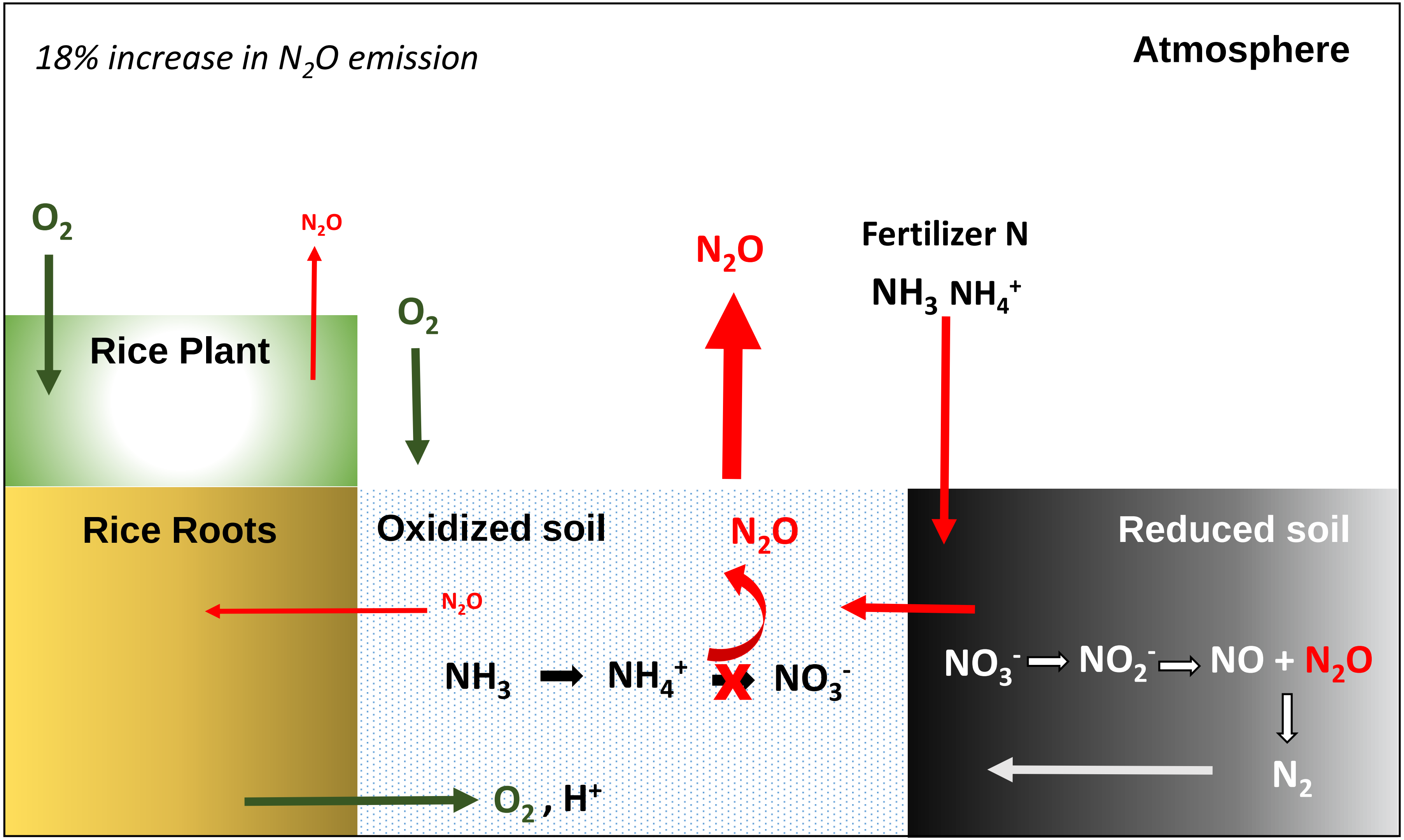
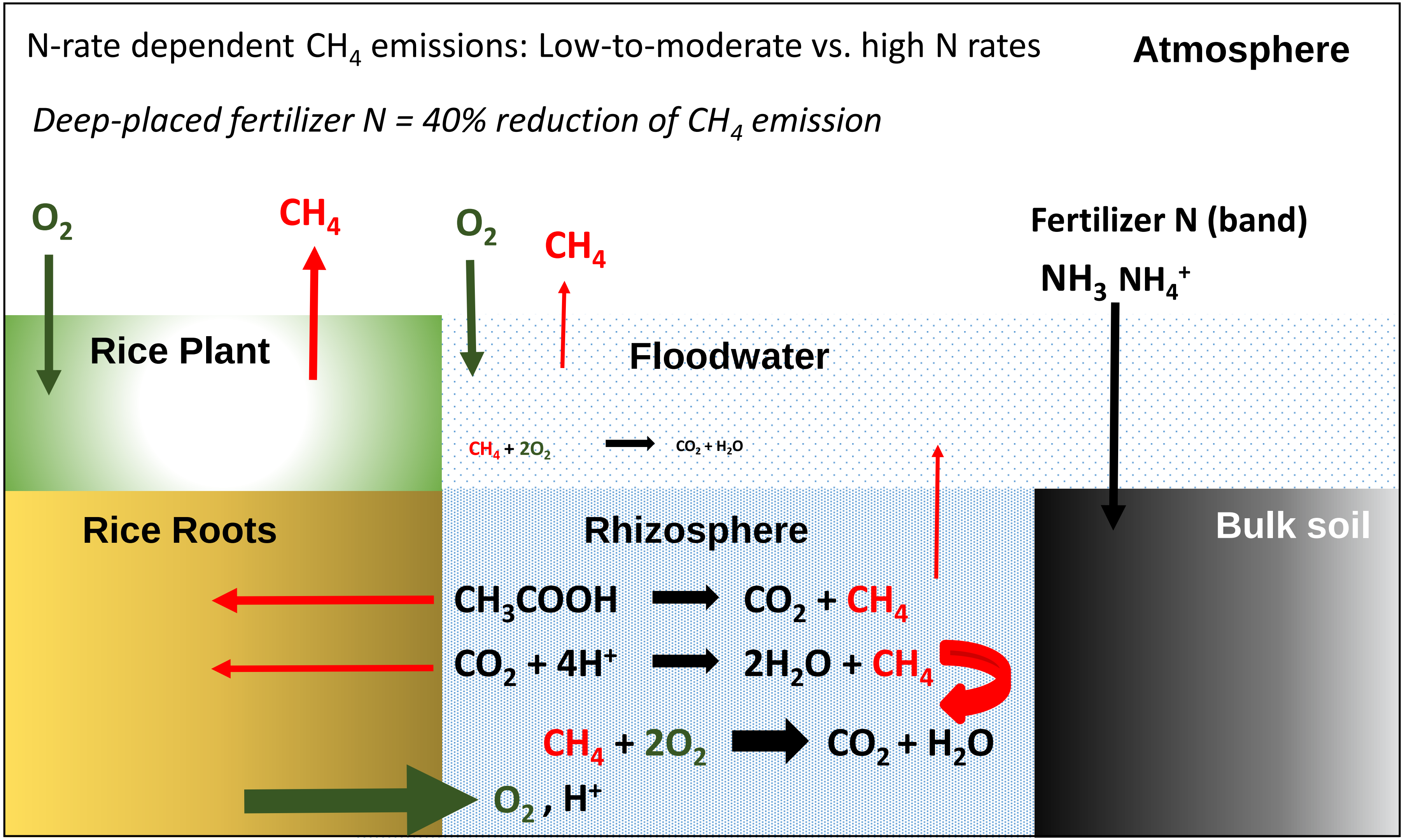
Influence of N fertilizer on N_2O emissions in flooded rice fields



Influence of N fertilizer on CH_4 emissions in flooded rice fields



Field experiments

Locations:

Field 1 – Agricultural Research Farm, University of California, Davis, CA

Field 2 – California Rice Research Experimental Station, Biggs, CA

Field 3 - Commercial rice grower's field, Marysville, CA

N treatments:

1. Broadcast N – surface applied N fertilizer
2. Banded N– injected/applied 7.5 cm below soil surface

Objectives

1. To asses various N fertilizer placements in reducing methane (CH_4) and nitrous oxide (N_2O) emissions from irrigated rice systems, and

2. To quantify grain yield under different N fertilizer management practices

N fertilizer treatments

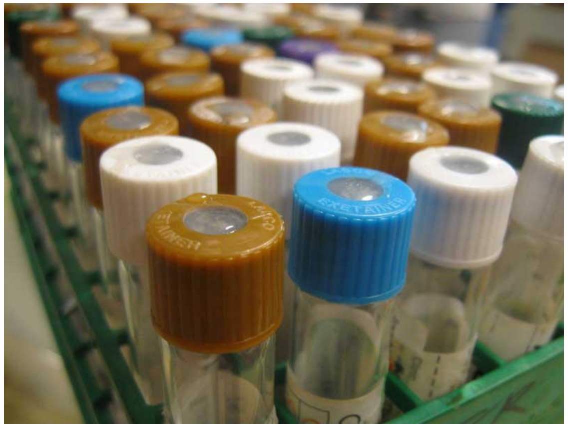
Site	Location	Rice variety	Treatment Code	Fertilizer N rate	Fertilizer Type	Location of Fertilizer N application[a]
				kg N ha^{-1}		
Field 1	UC Davis	M104	F1-N0	0	NA	NA
Field 1	UC Davis	M104	F1-BR	150	Urea	Surface
Field 1	UC Davis	M104	F1-BA	150	Urea	Subsurface
Field 2	RES, Biggs	M206	F2-N0	0	NA	NA
Field 2	RES, Biggs	M206	F2-BR	150	Urea	Surface
Field 2	RES, Biggs	M206	F2-BA	150	Urea	Subsurface
Field 3	Marysville, CA	M206	F3-N0	0	NA	NA
Field 3	Marysville, CA	M206	F3-BR	143	Urea	Surface
Field 3	Marysville, CA	M206	F3-BA	143	Urea	Subsurface

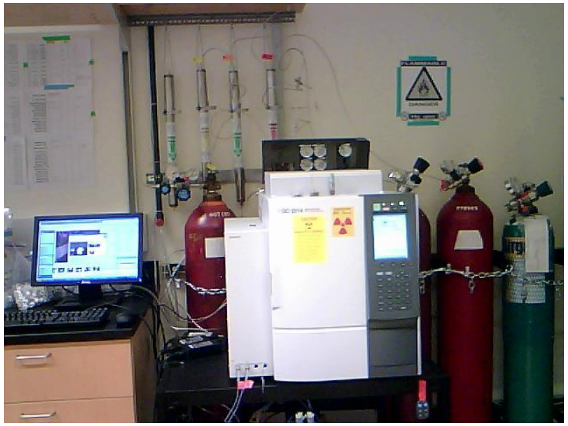
[a] subsurface application is placing urea 7.5 cm below the soil surface.

Measurements of CH_4 and N_2O emissions

- 30.5 cm diameter vented flux chamber with 17 CFM/5800 RPM fan
- daily to weekly gas sampling (90+ sampling dates)

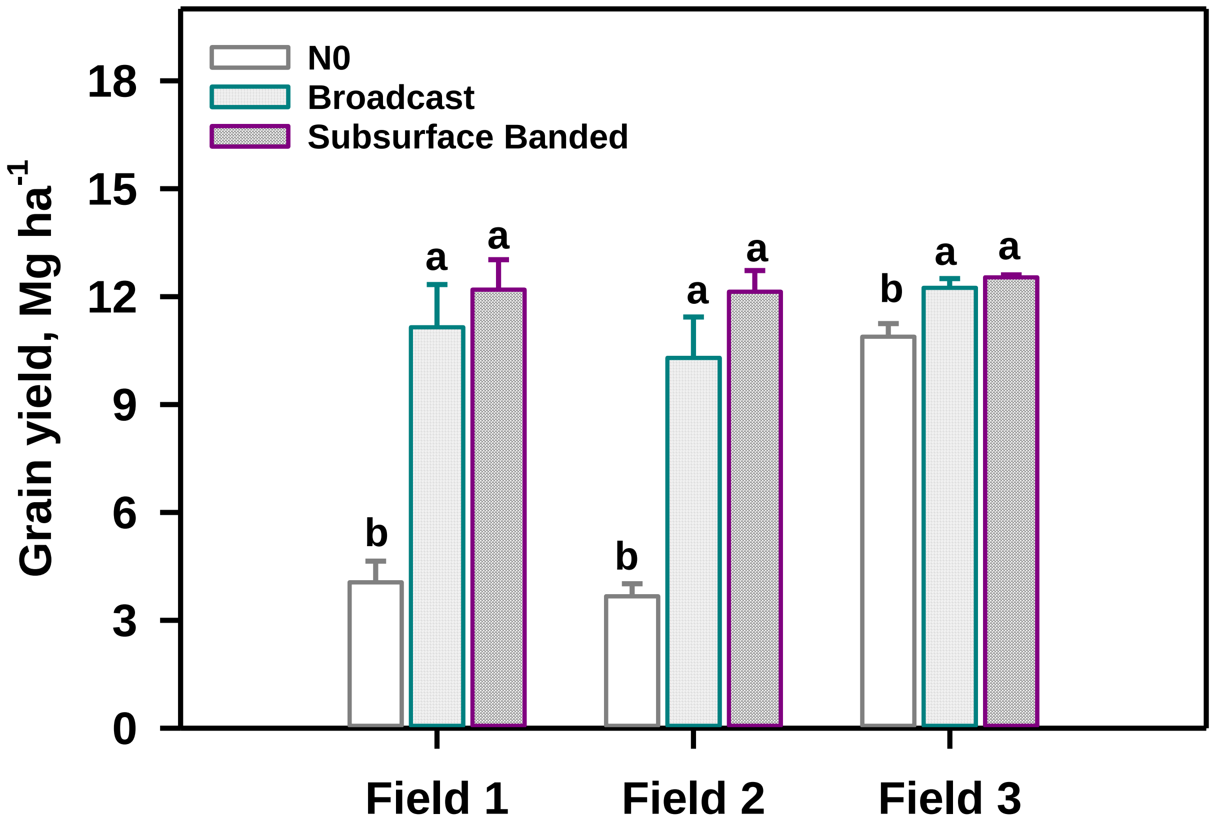
- varying chamber height (13 - 122 cm; 8-90 L) based on height of growing rice





- 12 mL gas vial double sealed with silicon
- Multi-point valves GC-2014 gas chromatograph with a ^{63}NI ECD and FID detectors

N fertilization affects grain yield

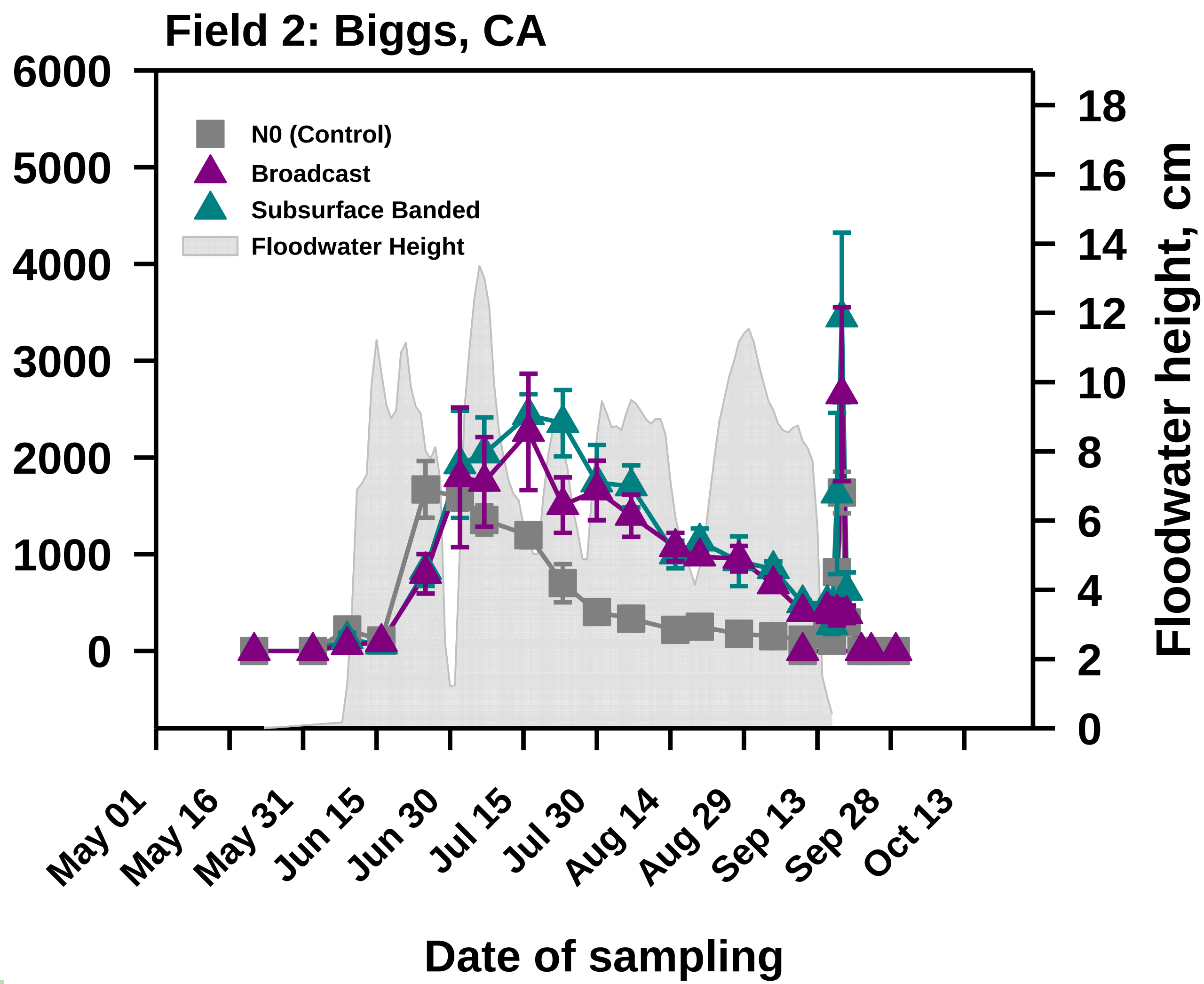


Significant at 95% confidence level

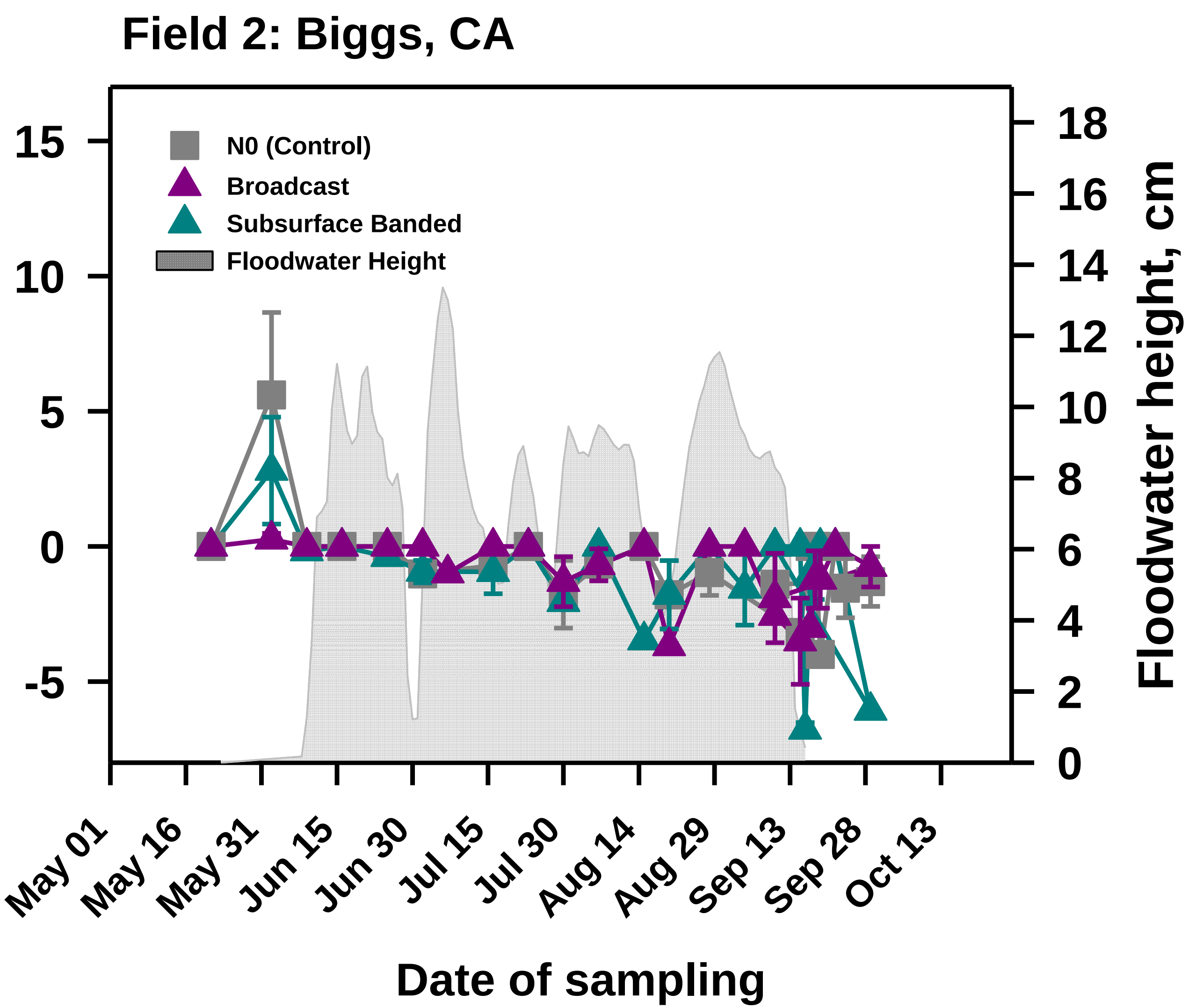
N fertilization affects grain yield

Fertilizer N placements	Grain Yield, Mg ha^{-1}	Relative % increase to surface application	Relative Yield change to surface application
Field 1			
N0	4.05b		
F1-BR	11.1a		
F1-BA	12.2a	10	1.1
Field 2			
N0	3.66b		
F2-BR	10.3a		
F2-BA	12.1a	17	1.8
Field 3			
N0	10.9b		
F2-BR	12.2a		
F2-BA	12.5a	2.5	0.3

N fertilizer placements and CH_4 emissions, kg CH_4-C ha^{-1} d^{-1}



fertilizer placements and N_2O emissions, g N_2O-N ha^{-1} d^{-1}



Global warming potentials and Fertilizer-induced N_2O emissions in different N treatments and sites

Fertilizer N placements	CH_4 emissions kg CO_2 eq ha^{-1} $season^{-1}$	N_2O emissions kg CO_2 eq ha^{-1} $season^{-1}$	Fertilizer-induced N_2O emissions, %
Field 1			
N0	210a	-6.6a	
F1-BR	409a	-23a	(0.02)
F1-BA	453a	-12a	(0.01)
Field 2			
N0	2,085b	-30a	
F2-BR	4,438a	-33a	(0.01)
F2-BA	3,834a	-50a	(0.04)
Field 3			
N0	8,994a	4.7a	
F2-BR	9,910a	-35a	(0.06)
F2-BA	7,711a	-6.0a	(0.02)

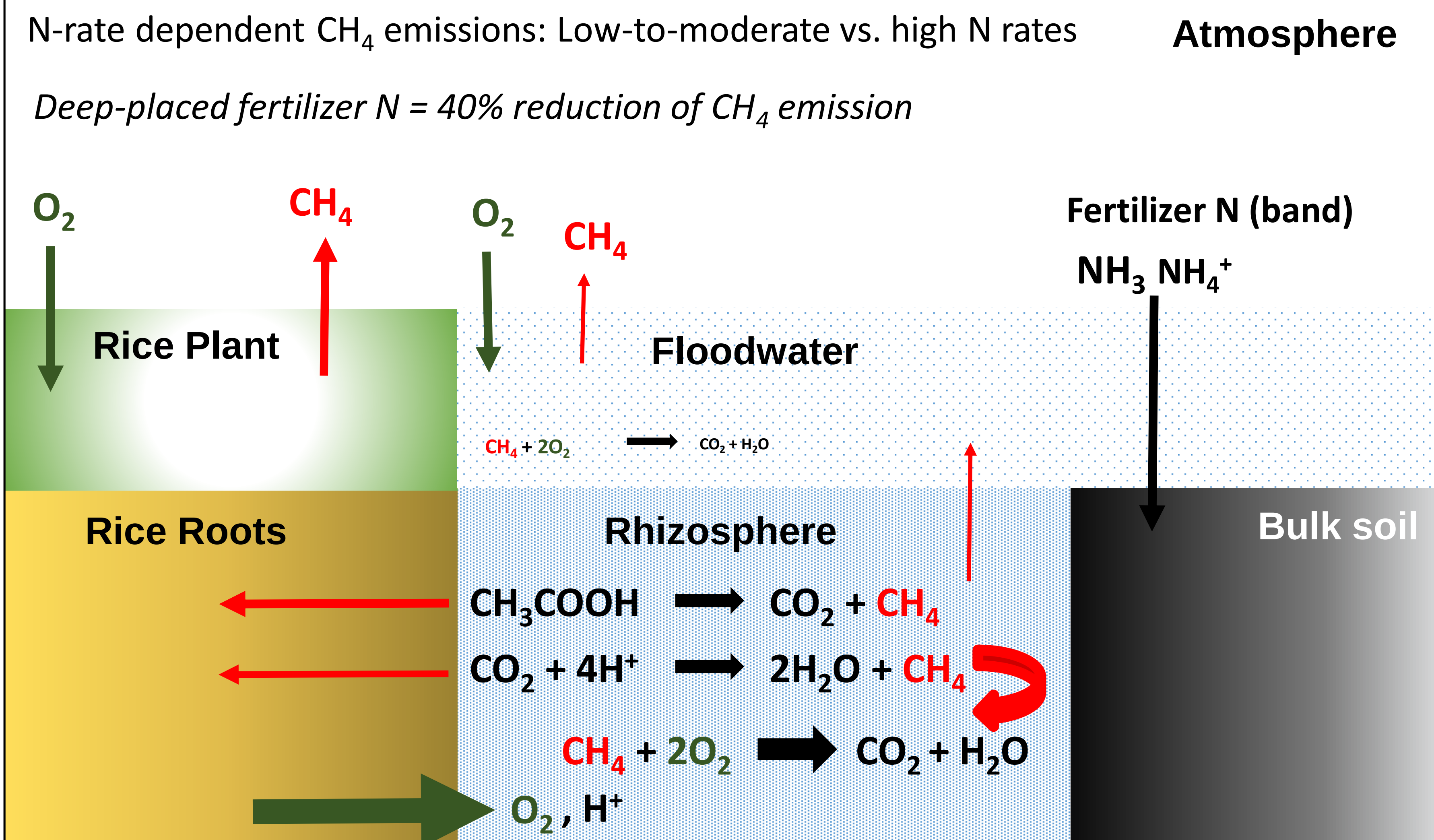
Global warming potentials in different N treatments and sites

Fertilizer N placements	GWP, kg CO_2 eq ha^{-1} $season^{-1}$	Relative % decrease to surface application	GWP_Y, kg CO_2 eq Mg^{-1} $season^{-1}$	Relative % decrease to surface application
Field 1				
N0	204a		46a	
F1-BR	385a		33a	
F1-BA	440a	(14)	35a	(6)
Field 2				
N0	2,055b		574a	
F2-BR	4,405a		449a	
F2-BA	3,784a	14	311a	31
Field 3				
N0	8,999a		824a	
F2-BR	9,875a		808a	
F2-BA	7,705a	22	616a	24

Influence of N fertilizer on CH_4 emissions in flooded rice fields

N-rate dependent CH_4 emissions: Low-to-moderate vs. high N rates

Deep-placed fertilizer N = 40% reduction of CH_4 emission



Summary

- Band application of urea fertilizer below the soil surface had no effect on the total seasonal CH_4 and N_2O emissions.

- Fertilizer addition increased grain yield in all study sites but the lack of yield response to N fertilizer placements is likely due to N was applied at optimal rates.

- More research is needed to evaluate if N placement can be an effective management practice to reduce GHG emissions in flooded rice systems.
  - soil depth (20 cm)
  - Form of fertilizer N; pellets vs granular

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Assessing fertilizer N placement on CH_4 and N_2O emissions in irrigated rice systems

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ABSTRACT

Improved N fertilizer management practices can increase rice yields and mitigate global warming potential (GWP). While banding N has been shown to have positive effects on yield and nitrogen use efficiency (NUE), there is little information on how it affects greenhouse gas (GHG) emissions from flooded rice systems. We tested the hypothesis that in continuously flooded rice systems where GWP is dominated by CH_4 emissions, deep placement of urea in bands would reduce CH_4 and N_2O emissions. Rice yields and GHG emissions were measured from three field experiments which had three treatments: (1) no N (N0), (2) urea broadcast (U-BR) on soil surface and (3) urea banded at 7.5 cm soil depth (U-BA). All urea was applied in a single application before flooding in preparation for planting at N rates of 143–150 kg N ha^{-1}. Throughout the rice growing season GHG emissions were measured using a vented flux chamber and gas chromatograph. Across all fields, N fertilizer application increased yield on average by 121%. Between the N placement methods, grain yields and NUE (37 kg grain kg^{-1}) were similar. Daily N_2O emissions were low to negative and did not differ among treatments. CH_4 emissions were the major source of GWP emissions and cumulative emissions ranged from 6.3 to 297 kg CH_4–C ha^{-1} $season^{-1}$ among fields. While in some cases fertilizer N increased CH_4 emissions, there was no effect of N placement on them.

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