



# Nitrous oxide sources and different nitrification pathways under various soil and environmental conditions

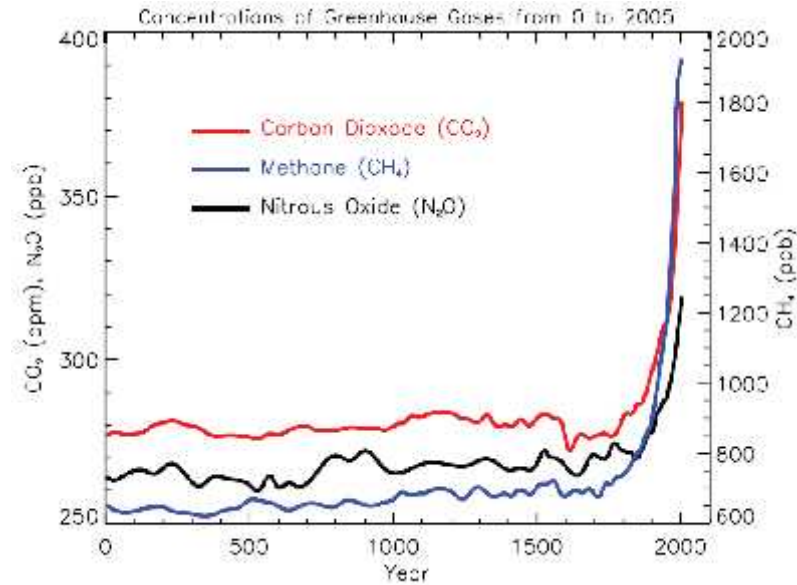
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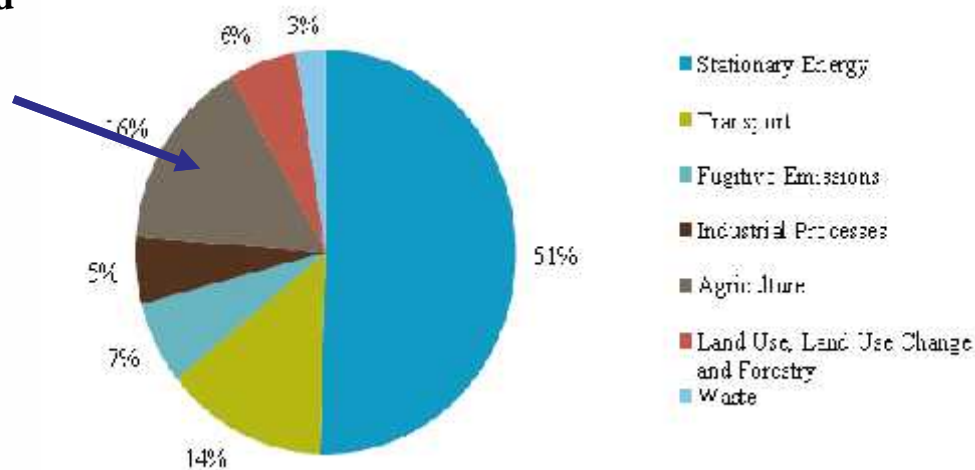
## **N<sub>2</sub>O concentration in atmosphere increased exponentially over last 100 years**

Concentration of greenhouse gases from 0 to 2005 (*Forster et al. 2007*)

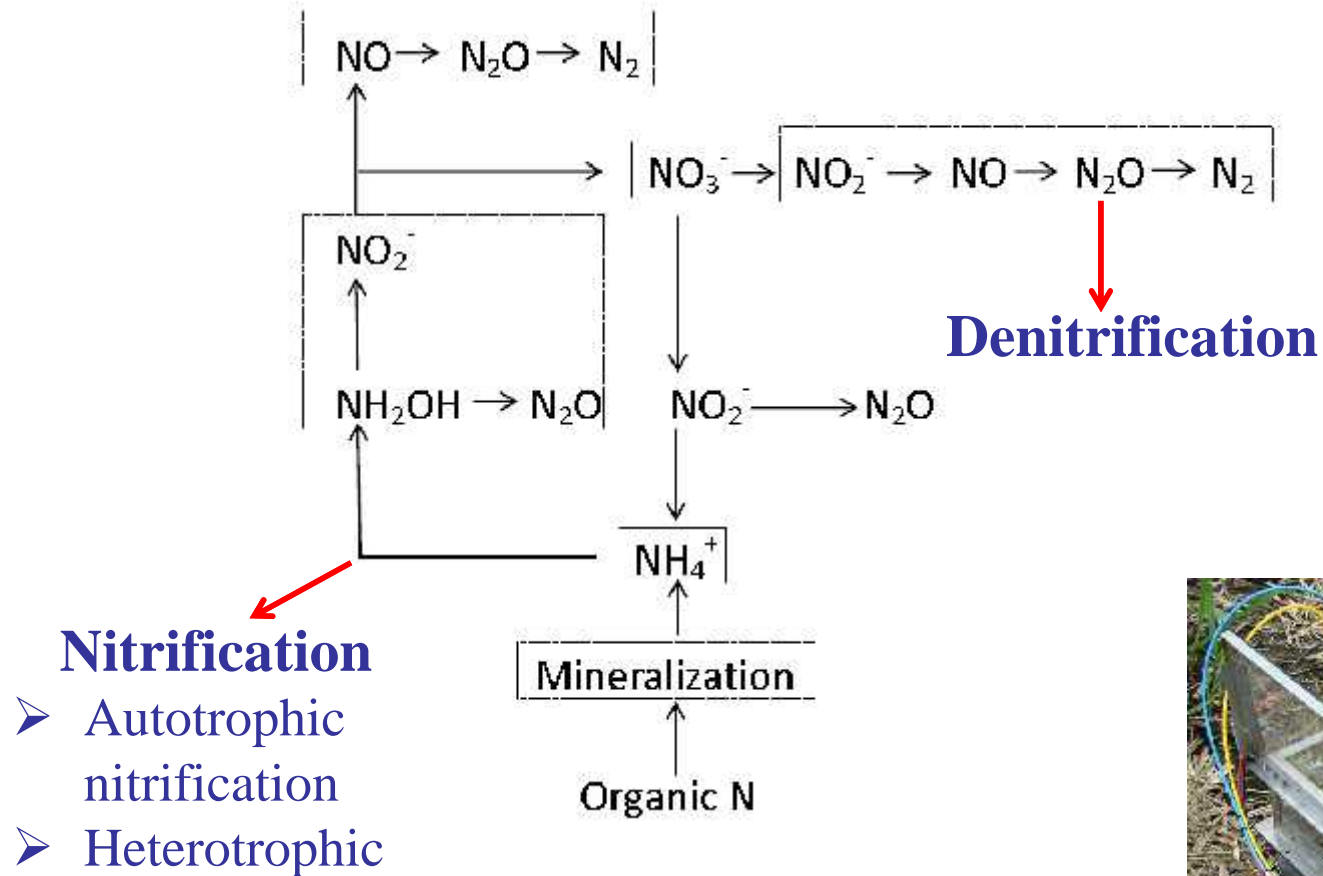


## **Agriculture is 2<sup>nd</sup> largest emitter:**

**75% CH<sub>4</sub> and 25% N<sub>2</sub>O**



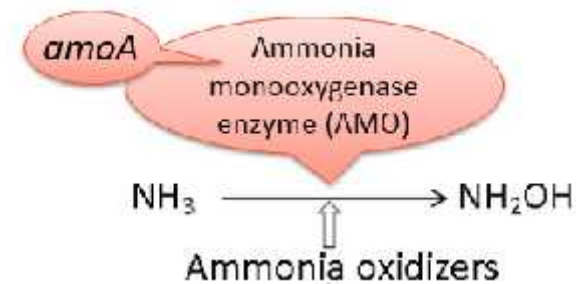
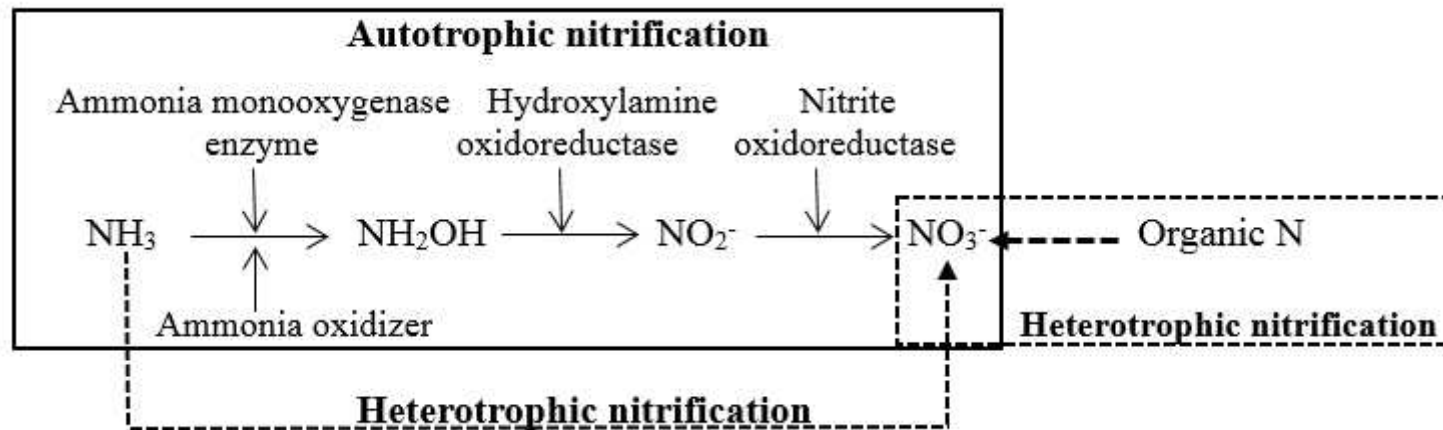
(*Dalal et al., 2003*)



**A great challenge to partition the relative contributions of all sources**



## Autotrophic and heterotrophic nitrification process



# Relative contribution of ammonia oxidizers to Nitrification

Ammonia-oxidizing  
archaea (AOA)

VS

Ammonia-oxidizing  
bacteria (AOB)



Environmental Microbiology (2009) 11(7), 1658–1671

doi:10.1111/j.1462-2820.2009.01891.x

RESEARCH ARTICLE

**Archaea rather than bacteria control nitrification in two agricultural acidic soils**

**Bacteria rather than Archaea dominate microbial ammonia oxidation in an agricultural soil**

Their contributions to soil N<sub>2</sub>O emissions and nitrification remain unclear!

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Edited by James M. Tiedje, Center for Microbial Ecology, East Lansing, MI, and approved August 30, 2010 (received for review April 13, 2010)

RESEARCH ARTICLE

**Growth of ammonia-oxidizing archaea in soil microcosms is inhibited by acetylene**

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LETTERS

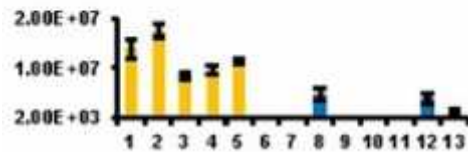
PUBLISHED ONLINE 30 AUGUST 2010 | DOI:10.1038/ngeo1361

**Nitrification driven by bacteria and not archaea in nitrogen-rich grassland soils**

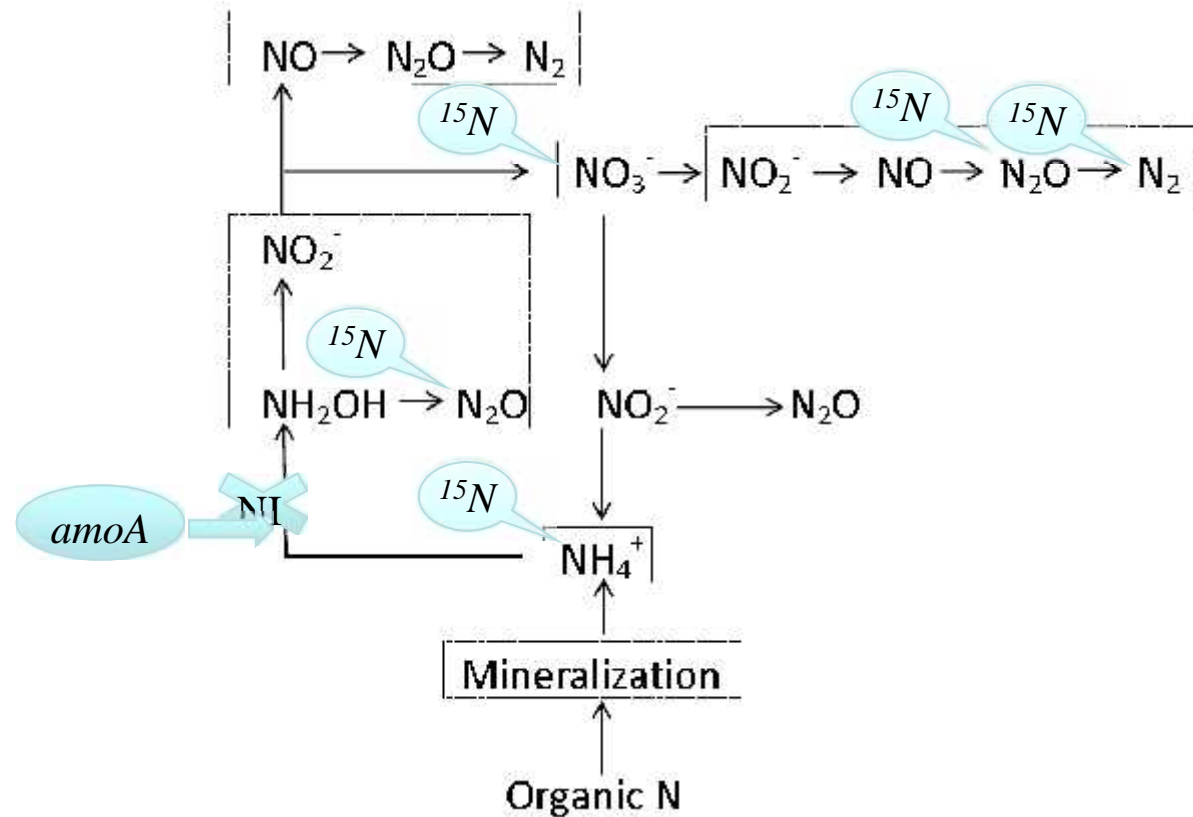
H. J. Di<sup>1,4</sup>, K. C. Cameron<sup>1</sup>, J. P. Shen<sup>2</sup>, C. S. Winefield<sup>3</sup>, M. O'Callaghan<sup>1</sup>, S. Bowatte<sup>2</sup> and J. Z. He<sup>2,4</sup>



Add soil sample  
and lysis to Bead  
Tube - VORTEX



Quantitative PCR





**The contribution of microbial pathways to N<sub>2</sub>O production in Australian agricultural soils:**

- the importance of heterotrophic nitrification
- the key factors affecting N<sub>2</sub>O emitted from nitrification
- the role of AOA and AOB in N<sub>2</sub>O production

## Laboratory microcosm incubations:

The relative contribution of biological pathways to  
N<sub>2</sub>O emission from different temperature and  
moisture



**The contribution of heterotrophic nitrification and autotrophic nitrification to total  $\text{N}_2\text{O}$  from different temperature and moisture**

	15C		25C		35C	
	50% WFPS	70% WFPS	50% WFPS	70% WFPS	50% WFPS	70% WFPS
Total $\text{N}_2\text{O}$ ( $\mu\text{g}/\text{cm}^2$ )	$0.11 \pm 0.03$	$1.38 \pm 0.68$	$0.21 \pm 0.05$	$15.39 \pm 6.45$	$0.46 \pm 0.40$	$64.42 \pm 1.20$
<b>Denitrification or heterotrophic nitrification (%)</b>	100.00	32.6	67.4	65.4	76.2	91.8
<b>Autotrophic nitrification (%)</b>	0	67.4	32.6	34.6	23.8	8.9

*(Liu et al. 2015)*

## The contribution of heterotrophic nitrification and autotrophic nitrification to total nitrification for different temperature and moisture

	50 % WFPS			70 % WFPS		
	15 °C	25 °C	35 °C	15 °C	25 °C	35 °C
Gross nitrification ( $\mu\text{g NO}_3\text{-N g}^{-1} \text{ soil day}^{-1}$ )	3.8 (1.1)	43.2 (7.9)	59.5 (6.4)	5.0 (1.3)	59.9 (5.2)	45.4 (1.4)
Heterotrophic nitrification (%) <sup>a</sup>	69.2	7.6	6.8	49.9	6.8	4.2
Autotrophic nitrification (%)	30.8	92.4	93.2	50.1	93.2	95.8

Values in brackets are standard deviation ( $n=3$ )

<sup>a</sup> Percent heterotrophic nitrification was calculated as heterotrophic nitrification rate/gross nitrification rate  $\times$  100 %

(Liu et al. 2015)

## Laboratory microcosm incubations:

The relative contribution of biological pathways to  $\text{N}_2\text{O}$  emission from different agricultural soils



Sugarcane



Cropping



Vegetable



Dairy pasture

## N<sub>2</sub>O Derived from Nitrification

Land-use	Gross nitrification rate mg N kg <sup>-1</sup> d <sup>-1</sup>	Relative contribution %		N <sub>2</sub> O <sub>d</sub> μg N <sub>2</sub> O-N cm <sup>-2</sup> d <sup>-1</sup>	N <sub>2</sub> O <sub>n</sub>	P <sub>N<sub>2</sub>O</sub> ‰
		Deni	Nitri			
<b>Sugarcane</b>	1.70 (0.50)	3.30 (0.45)	96.67 (6.8)	0.80 (0.03)	23.40 (0.34)	0.030 (0.0016)
<b>Vegetation</b>	5.42 (0.43)	76.36 (9.2)	23.64 (3.91)	53.65 (7.03)	16.63 (3.30)	0.024 (0.0011)
<b>Dairy Pasture</b>	3.84 (0.78)	29.09 (4.1)	70.90 (4.97)	20.24 (1.22)	49.85 (8.34)	0.033 (0.0026)
<b>Cropping</b>	9.88 (2.30)	28.74 (8.6)	71.26 (1.82)	134.34 (4.06)	334.47 (6.63)	0.260 (0.0189)

<sup>a</sup> The relative contribution by denitrification (Cd) to N<sub>2</sub>O production

<sup>b</sup> The relative contribution by nitrification (Cn) to N<sub>2</sub>O production.

<sup>c</sup> N<sub>2</sub>O production from nitrification (N<sub>2</sub>O<sub>n</sub>).

<sup>d</sup> N<sub>2</sub>O production from denitrification (N<sub>2</sub>O<sub>d</sub>).

<sup>e</sup> The proportion of nitrified N emitted as N<sub>2</sub>O (P<sub>N<sub>2</sub>O</sub>).

Values in bracket are standard deviations.

*(Liu et al. 2016)*

## Laboratory microcosm incubations:

The relative contribution of AOA and AOB to N<sub>2</sub>O emission and nitrification

## Correlations between soil mineral N levels, N<sub>2</sub>O<sub>n</sub><sup>a</sup> and AOA and AOB abundances

Time	Factor	AOA (Log number)		AOB (Log number)	
		R	P-Values	R	P-Values
Before fertilizer applied	Exchangeable NH <sub>4</sub> <sup>+</sup> concentration	0.454	0.138	0.089	0.779
	NO <sub>3</sub> <sup>-</sup> concentration	0.217	0.499	0.063	0.846
	N <sub>2</sub> O <sub>n</sub>	0.615	0.033	0.517	0.085
After fertilizer applied	Exchangeable NH <sub>4</sub> <sup>+</sup> concentration	0.623	5.00E-05	0.535	0.008
	NO <sub>3</sub> <sup>-</sup> concentration	-0.622	5.07E-05	-0.369	0.027
	N <sub>2</sub> O <sub>n</sub>	0.346	0.038	0.578	0.0002

<sup>a</sup> means N<sub>2</sub>O production from nitrification

*(Liu et al. 2016)*



# Conclusions

- ✓ Soil temperature and moisture significantly influenced the relative contributions of heterotrophic and autotrophic nitrification to total nitrification and N<sub>2</sub>O emission
  - ✓ The relative contributions of N<sub>2</sub>O sources differed between soils.
  - ✓ Soil moisture and temperature, and land-use influence the role of AOA and AOB in nitrification.
  - ✓ Heterotrophic and autotrophic nitrification can not be separated by detecting *amoA*
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# Thank you!

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