Greenhouse gas emissions from animal manure

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Greenhouse gas sources, manure management

Housing

Storages

Drylots/pastures

Methane

Nitrous oxide

Ammonia/NOx

Cattle management practises

Housing vs. grazing

Day and night grazing	45%
Day-only grazing	45%
Zero-grazing	10%

(Schils et al., 2002)

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Manure management

Manure storage conditions

In-house storage time?

Slurry storage cover?

Mitigation measures?

Composting or not?

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IPCC methodology
N_2O emission factors, AWMS

Main categories	**EF**	**Uncertainty (%)**
Liquid/slurry	0.001	-50 to +100
Solid manure#	0.02	-50 to +100
Dry lots	0.02	-50 to +100
Pastures	0.02	-50 to +100

≥20% DM

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IPCC methodology
Methane conversion factors (Cool)

Source	**MCF**
Pasture/drylot	1%
Solid storage	1%
Liquid storage	39%
Slurry channels	
<1 month	0%
>1 month	39%
Anaerobic digestion	0-100%

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Manure management

Sources of variability

Solid manure storage conditions

- effects of aeration

Liquid manure storage conditions

- effects of climate and cover

Excretal returns to the pasture

- effects of spatial heterogeneity

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Solid manure storage

Effect of aeration on MCF

Source	**IPCC**
Pasture/drylot	1%
Solid storage	**1%**
Liquid storage	39%
Slurry channels	
<1 month	0%
>1 month	39%
Anaerobic digestion	0-100%

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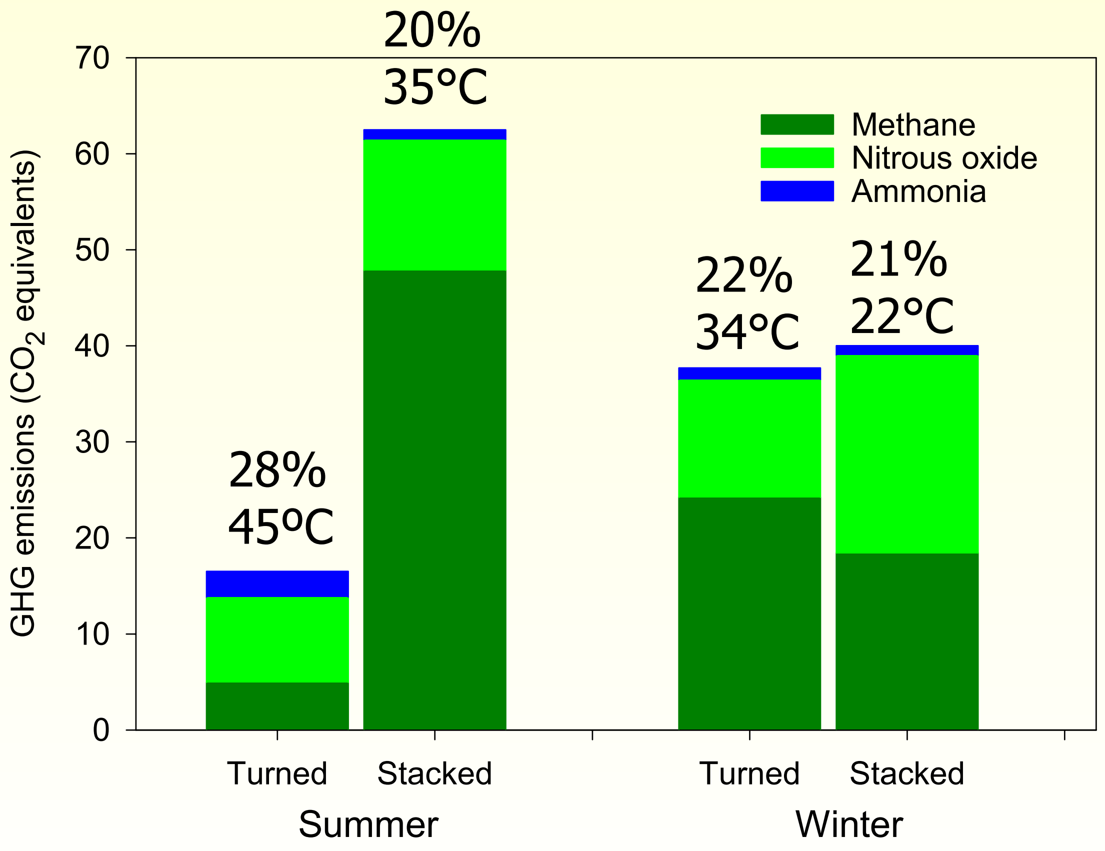
Solid manure storage

Effect of season, turning and DM content on GHG emissions



(Amon et al., 2001)

Solid manure storage

Distinction, composting or not?

Amon (2001)	0.4-3.9%
US EPA	0.1-5%
Gibbs & Woodbury (1993)	1-2%

Manure, composting MCF = 1%?
Manure, not composting MCF = 5%?

Solid manure storage

IPCC emission factor for N_2O

Main categories	EF	Uncertainty (%)
Liquid/slurry	0.001	-50 to +100
Solid manure[#]	**0.02**	-50 to +100
Dry lots	0.02	-50 to +100
Pastures	0.02	-50 to +100

[#] ≥20% DM

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Solid manure storage

Experimental N_2O emission factors

Material	Storage time (d)	EF	Ref.
FYM, cattle	120	0.003-0.007	1
+ straw	120	0.003-0.005	
FYM, cattle	80 (winter)	0.004	2
+ turned		0.007	
FYM, cattle	80 (summer)	0.003	
+ turned		0.004	
FYM, cattle	?	<0.01	3
FYM, pig	90	<0.005	4

[1] Yamulki (MIDAIR); [2] Amon et al. (2001, recalc.);[3] Amon et al. (1997); [4] Petersen et al. (1998)

Solid manure storage
Conclusions

- composting may significantly reduce CH_4 emissions from solid manure
- trade-off with NH_3 volatilization; losses during composting can exceed 10% of total N
- an N_2O emission factor of 0.02 may be too high

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Liquid manure storage

IPCC emission factors for CH_4

Source	**MCF**
Pasture/drylot	1%
Solid storage	1%
Liquid storage	**39%**
Slurry channels	
<1 month	**0%**
>1 month	**39%**
Anaerobic digestion	0-100%

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Liquid manure storage

IPCC emission factors for CH_4

$$F_T = [VS_d \times b_1 + VS_{nd} \times b_2] \times \exp[\ln(A) - E/RT]$$

F_T	CH_4 emission rate (g CH_4 d^{-1})
VS_d	digestible volatile solids (g kg^{-1})
VS_{nd}	‘non-digestible’ volatile solids (g kg^{-1})
b_1, b_2	rate correcting factors (no dimensions)
A	Arrhenius parameter (g CH_4 kg^{-1} VS h^{-1})
E	apparent activation energy (J mol^{-1})
R	gas constant (J K^{-1} mol^{-1})
T	temperature (K)

Time steps: 1 day.

(Sommer et al., unpublished)

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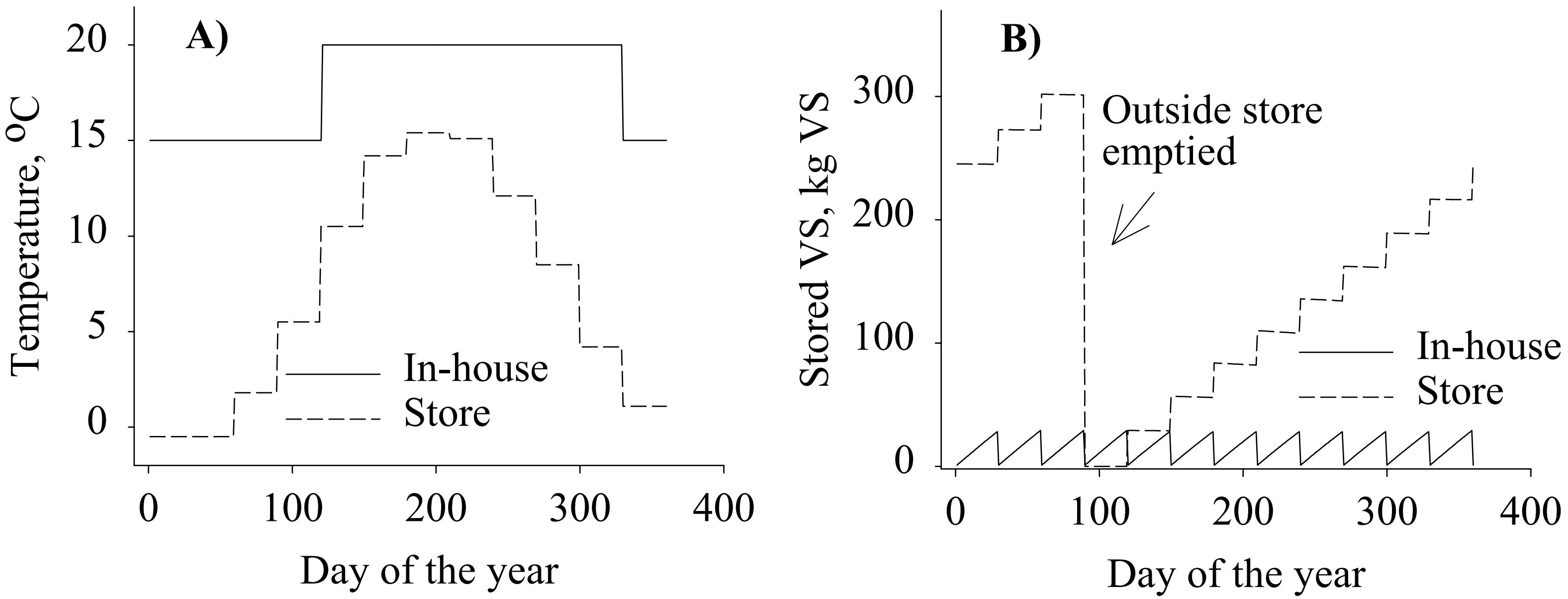
Liquid manure storage

Storage conditions modelled



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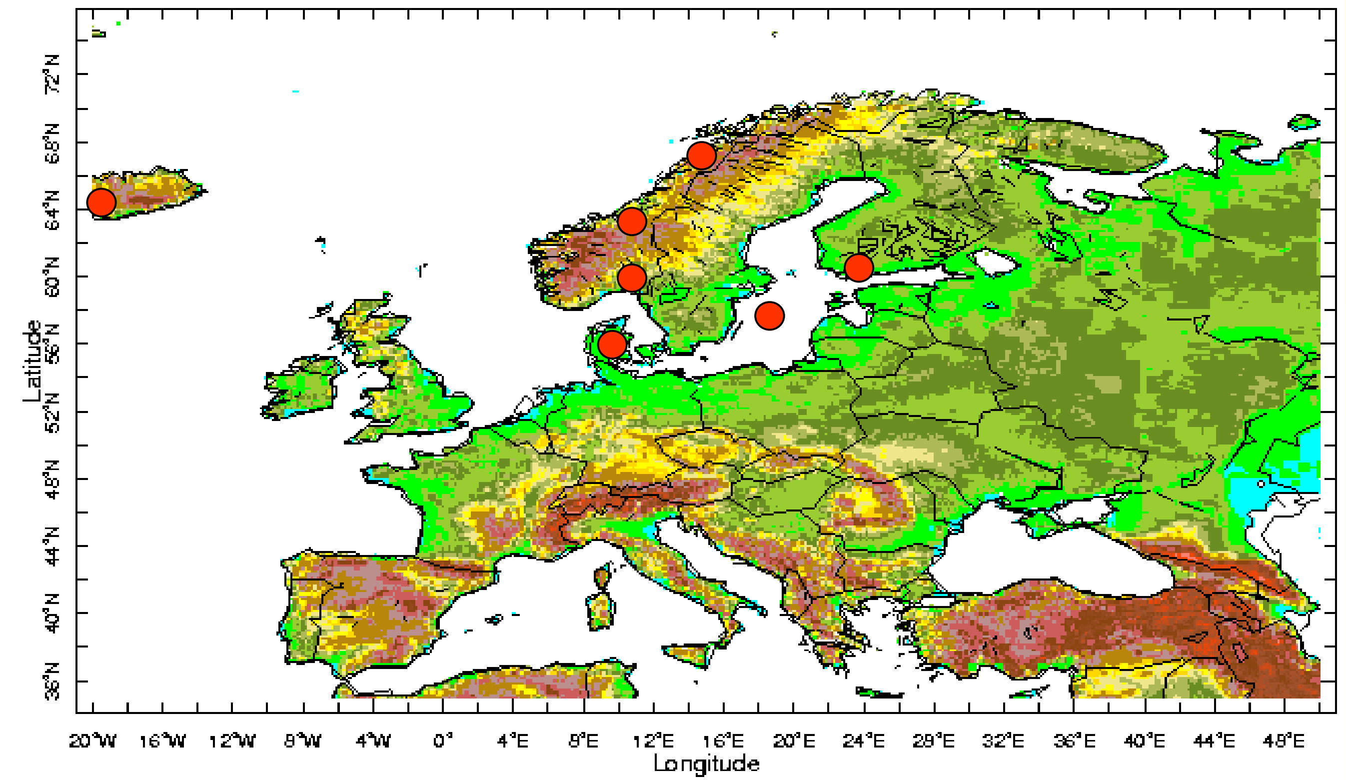
Manure management

Methane emissions from slurry, locations



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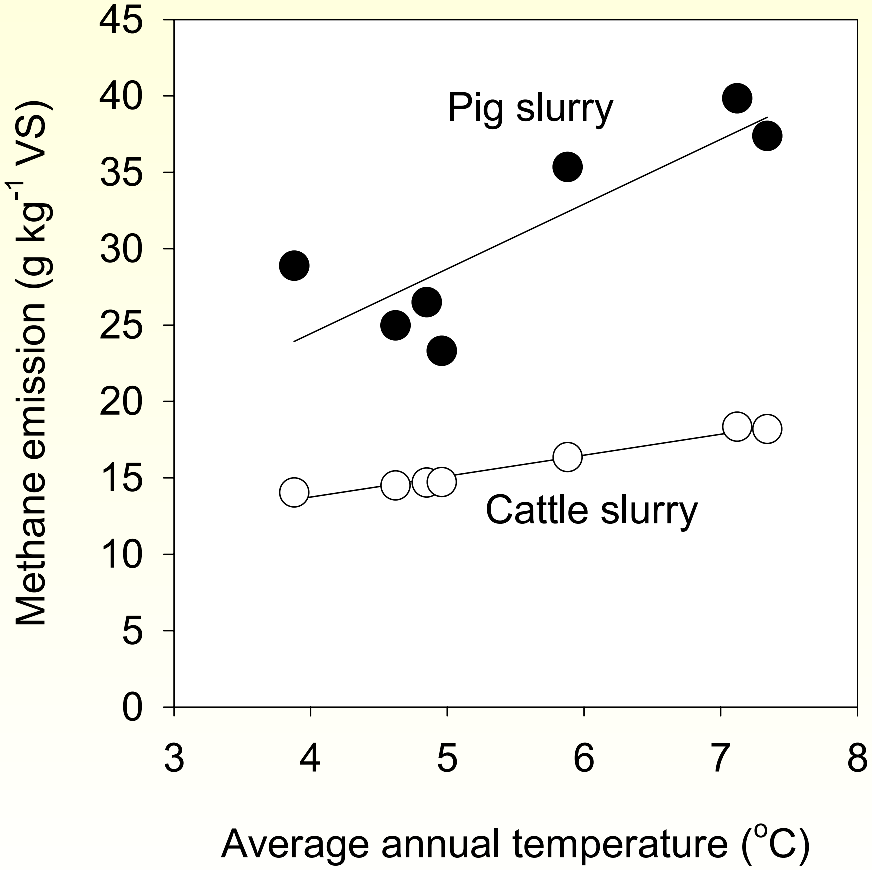
Manure management

Methane vs. average annual temperature



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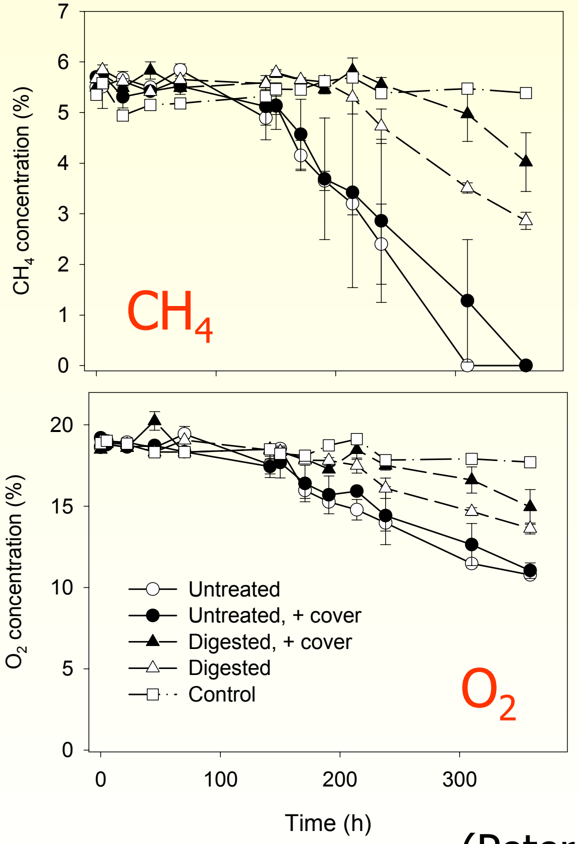
Liquid manure storage

Methane oxidation in surface crust



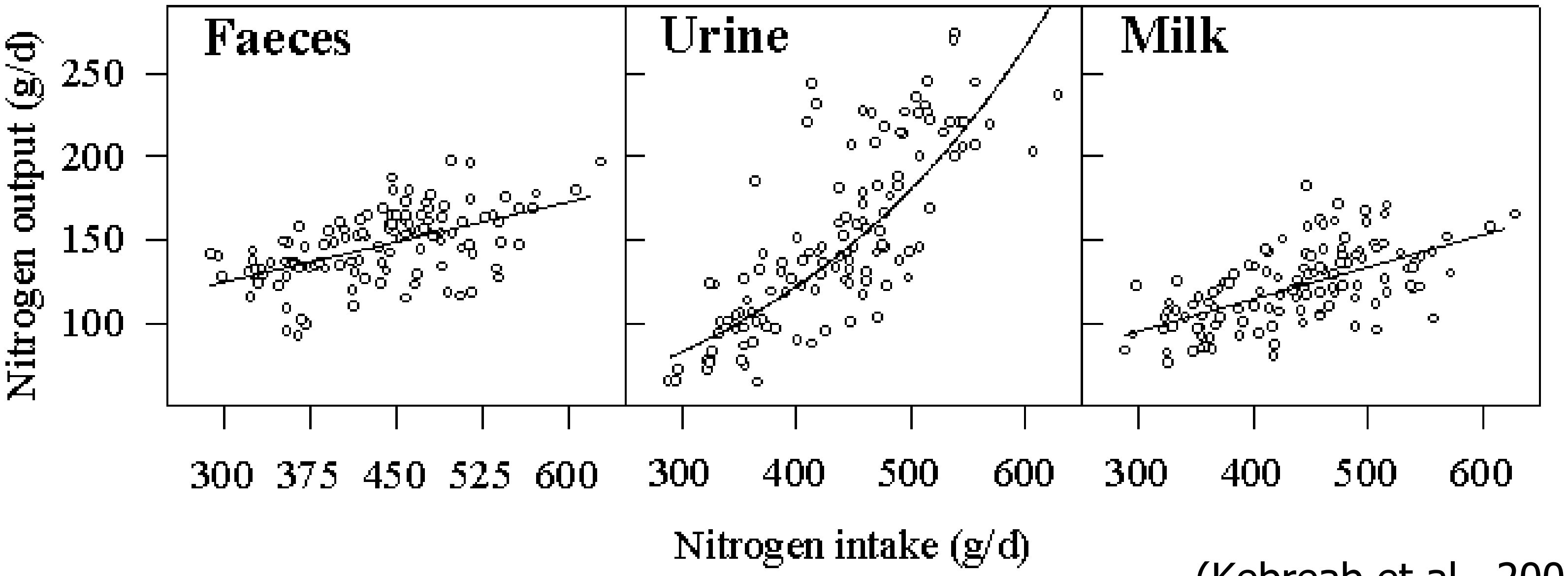
(Petersen, MIDAIR)

Liquid manure storage
Conclusions

- storage temperature has strong effect on CH_4 emissions from slurry, and should be more well-defined
- a simple algorithm may be able to account for seasonal and geographic temperature variation
- interactions of surface crusts and covers with CH_4 emissions should be investigated

Excretal returns

Urine vs. dung



(Kebreab et al., 2001)

Surplus N in diet → Urea-N in urine

IPCC methodology

N_2O emission factors, AWMS

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[#] ≥20% DM

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Excretal returns

N_2O emission factor, urine patches

Soil type	N_2O-N (fraction of urine-N)	Length of period (d)	Application rate (g N m^{-2})	Ref.
Silt loam	0.008	406	100	1
Sandy loam	0.010	406	100	1
Peat	0.019	406	100	1
Clay	0.019	406	100	1
Silty clay loam	0.010	100	54	2
Peat	0.022	31	c. 210	3
Sandy silty loam	0.014-0.042	357	101 (spring)	4
	0.003-0.009	357	101 (autumn)	4

[1] Clough et al. (1998); [2] Yamulki et al (1998); [3] Koops et al. (1997); [4] Anger et al. (2003)

Excretal returns

N_2O emissions, influencing factors

- urine composition
- excretion rate
- WFPS
- compaction
- soil inorganic N

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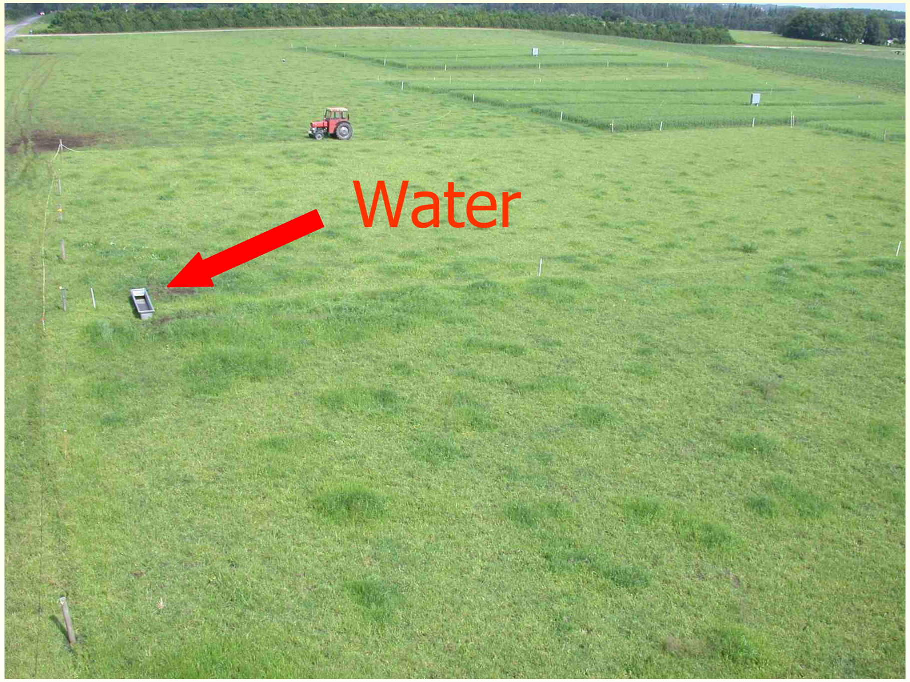
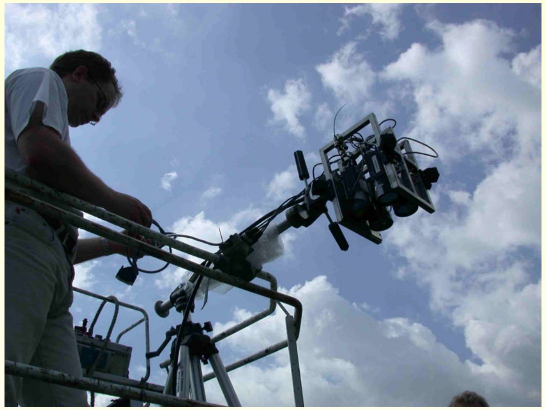
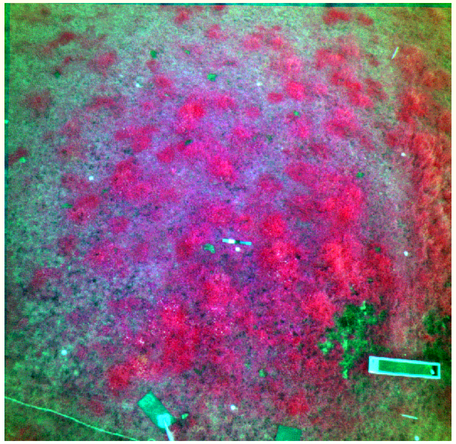
Excretal returns

Field-scale heterogeneity







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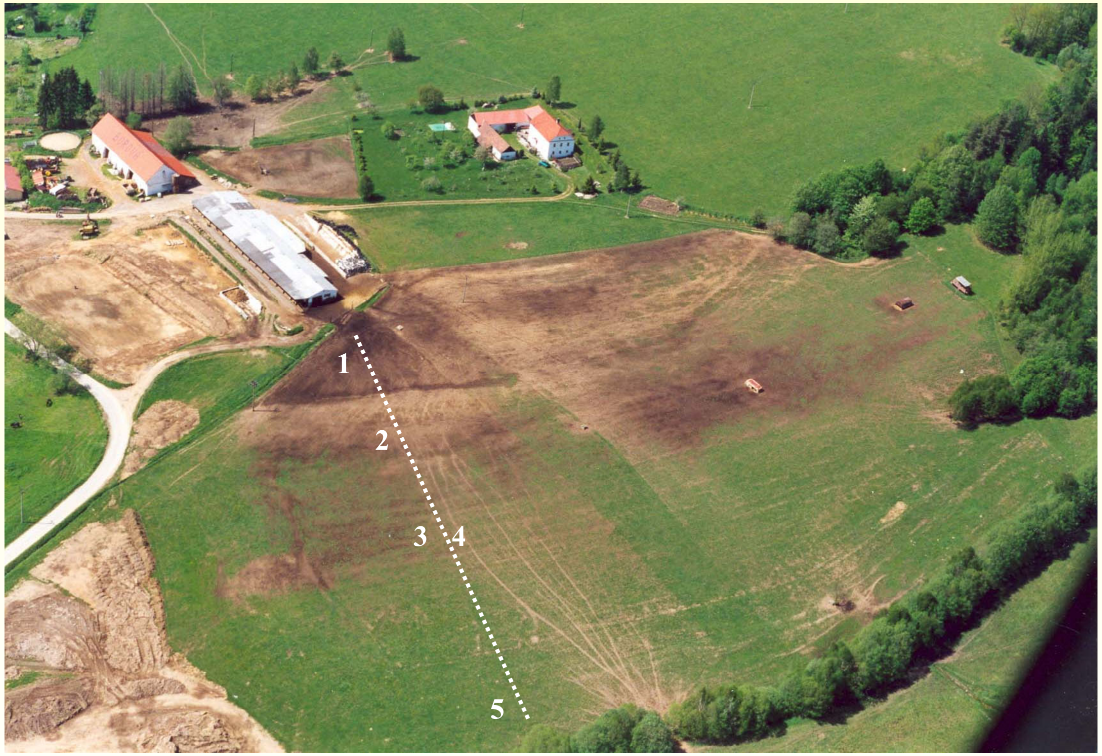
Excretal returns

Heterogeneity in winter pasture



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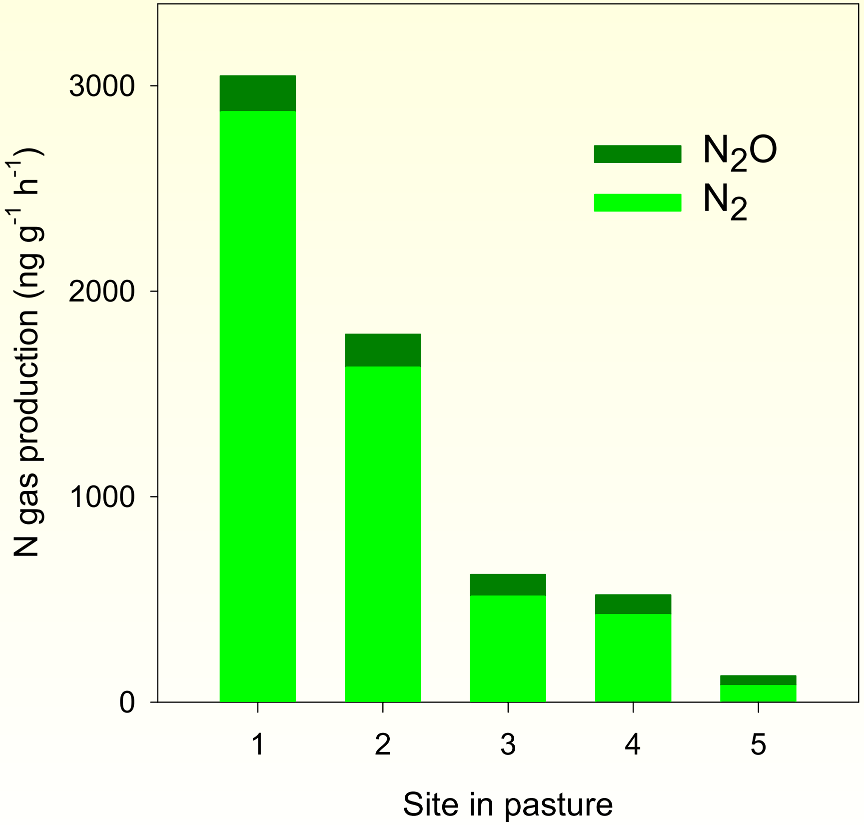
Excretal returns

Denitrifying enzyme activity



(Simek et al., MIDAIR)

Excretal returns

Conclusions

Interactions between excreta, soil conditions and N_2O emissions not well understood.

Field-scale gradients of animal impact can be identified, but there is no simple relation to N_2O emissions.

Possibly the only effective mitigation strategy is to reduce the N excretion via optimized feeding or extensification.

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Case: Dairy cattle grazing

GHG balance for the grazing season 1994

Two systems: Fertilized grass and grass-clover

N intake (from pasture and feeds): 505 g N/cow/d)

Length of grazing season: 162 d

Stock density: 5.2 or 4.4 cows/ha for grass and grass-clover

Not included: GHG associated with feed production, manure application

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Case: Dairy cattle grazing

N balance for the grazing season 1994

	Fertil. grass	Grass-clover
	(kg N/ha)	
Fertilizer N	300	0
BNF	0	232
N excretion	222	194
N deposition	14	14
Grass intake	-293	-249
Manure storage	95	83

(Søegaard et al., 2001)

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Case: Dairy cattle grazing

GHG emissions for grazing season 1994

	Fertilized grass		Grass-clover	
	(CO_2-C eq/ha)			
	CH_4	N_2O	CH_4	N_2O
Fertilizer N	-	488	-	0
BNF	-	0	-	385
N excretion	-	472	-	412
NH3 volatilization	-	67	-	52
N leaching	-	520	-	424
Manure storage	297	13	252	11
Animals	1582	-	1338	-

Case: Dairy cattle grazing

GHG emissions for grazing season 1994

	Fertilized grass	Grass-clover
t CO_2-C eq/ha	**3.4**	**2.9**
t CO_2-C eq/LU	**0.66**	**0.65**

C sequestration potential by grassland management (Soussana et al., in press):

Annual rate **0.2-0.5 t C/ha**

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Conclusions

- The large uncertainty of IPCC default emission factors for manure management is partly due to ill-defined storage conditions and manure properties, and further disaggregation is needed.

- The potential for composting has a large impact on C and N transformations in solid manure, and a distinction between composting and non-composting manure is proposed.

- Nitrous oxide emissions from solid manure may be less than 2%.

- Methane production in stored slurry is strongly temperature dependent, simple methods may account for seasonal and geographic variation in temperature.

- There is little potential for reducing N_2O emissions from excretal returns to pastures, except by an increase in N use efficiency.

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