Modelling seasonal dynamics from temporal variation in agricultural practices in the UK ammonia emission inventory

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Presentation

1. Background (ammonia emissions & spatial emission inventories)
2. Monthly emission factors
3. The AENEID model (monthly)
4. Results – Monthly emission maps
5. Conclusions

Ammonia emissions, NH_3

Main effects

Eutrofication of nitrogen sensitive ecosystems

Acidification

Main source

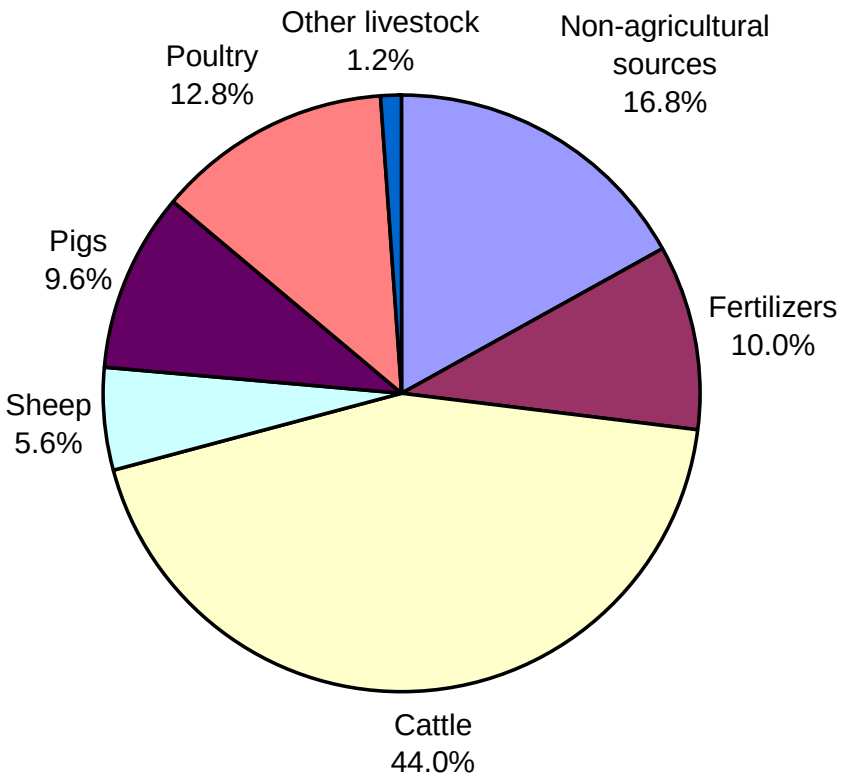
Agriculture - 83 % in the UK

(manure and fertilizers)

Behaviour

Deposits close to its sources

--> Large spatial variations over the country



Why spatial emission inventories?

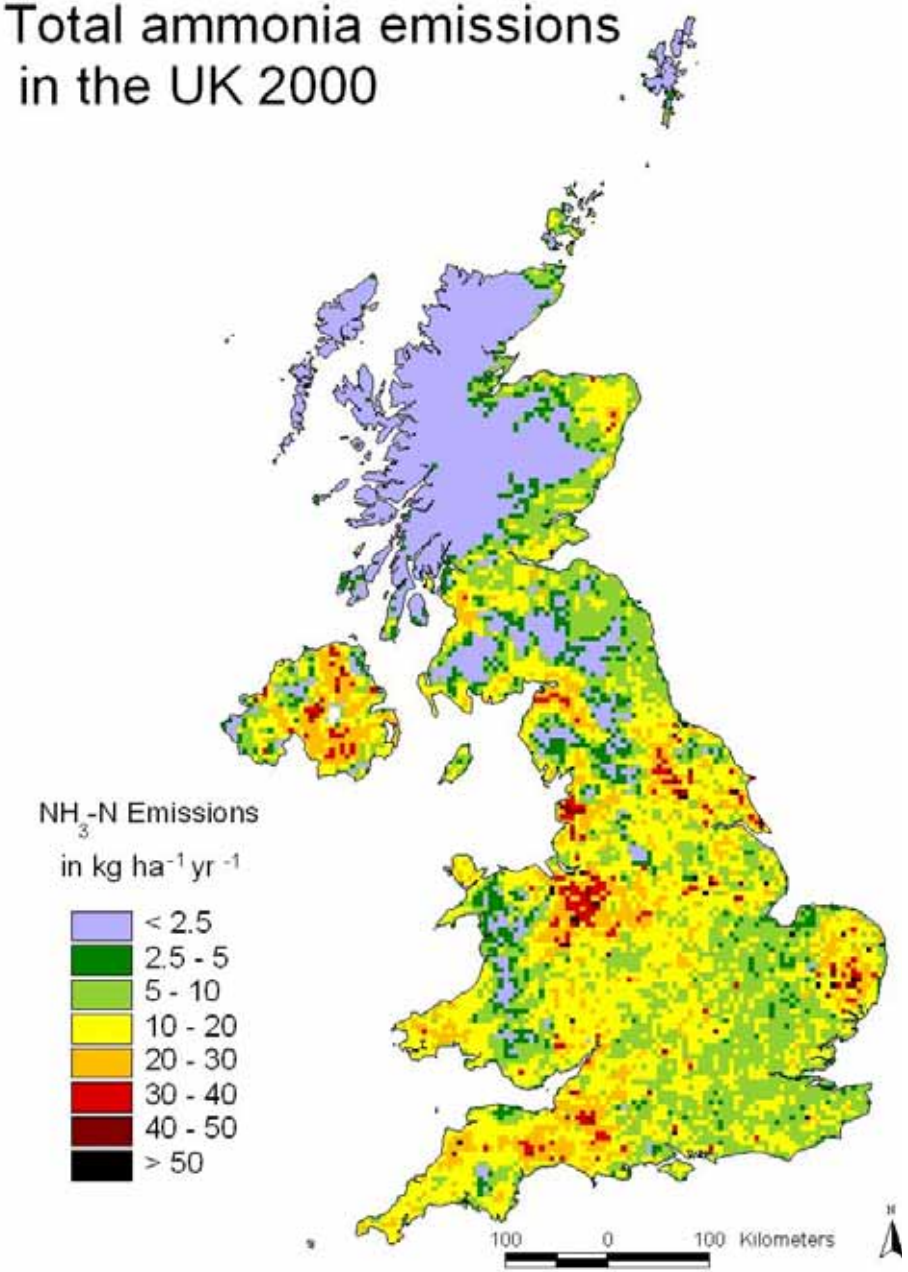
Provides pollution information and identifies activities responsible for pollution

Tool to evaluate the effects of different abatement strategies

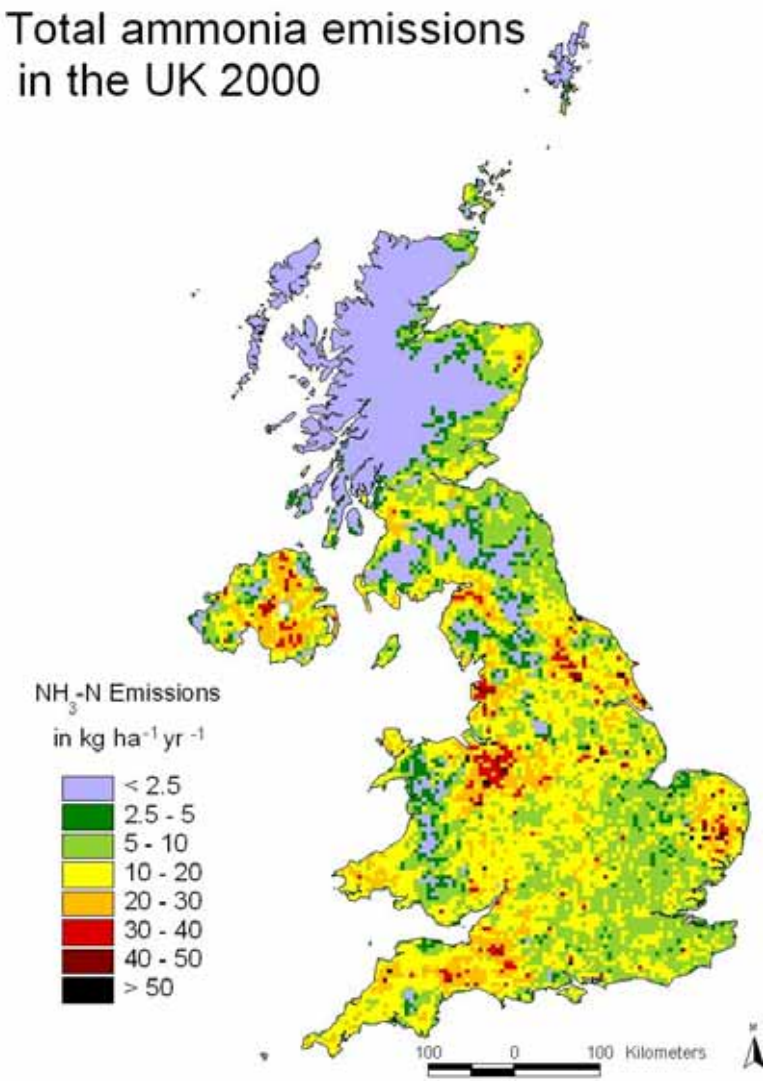
Why monthly emission inventories?

Annual ammonia emission maps fail to capture seasonal variations in emissions

- identify when monthly threshold levels of ammonia are exceeded
- identify when abatement measures should be implemented
- be used as input to atmospheric transport models to interpret the seasonal dynamics in NH_3 dispersion and deposition



Annual NH_3 Maps fail to capture seasonal variations in emissions



Ammonia emissions vary during the year due to seasonal variations in:

a) Agricultural Practice
The grazing & housing season
Manure spreading
Fertilizer application

b) Environmental conditions
Temperature
Precipitation

→ **2 types of variations:**

1) Variations in magnitude
2) Variations in location

IAEUK - Inventory of agricultural Ammonia Emissions in the UK

A) **Fertilizer application**

B) **Manure management**

1. Livestock grazing
2. Livestock housing
3. Manure storage
4. Manure application to the fields

IAEUK calculates annual NH_3 emissions using emission factors for each livestock class for each of the various manure management stages

Annual emissions

Example: The annual UK emission from dairy cows during housing in cubicles

Emission factor: 38.2 g NH_3-N lu^{-1} d^{-1}

Activity data:

number of dairy cows in the UK	2,633,357 dairy cows
percentage of dairy cows kept in cubicle houses	66 %
number of days per year spent housing	205 days

14.6 kt NH_3-N yr^{-1}

Monthly emissions - June

Example: The monthly UK emission from dairy cows during housing in cubicles

Emission factor: 38.2 g NH_3-N lu^{-1} d^{-1}

Activity data:

number of dairy cows in the UK	2,633,357 dairy cows
percentage of dairy cows kept in cubicle houses	66 %
number of days in May spent housing	0 days

0 kt NH_3-N yr^{-1}

Monthly emissions - December

Example: The monthly UK emission from dairy cows during housing in cubicles

Emission factor: 38.2 g NH_3-N lu^{-1} d^{-1}

Activity data:

number of dairy cows in the UK	2,633,357 dairy cows
percentage of dairy cows kept in cubicle houses	66 %
number of days in December spent housing	31 days

2.2 kt NH_3-N yr^{-1}

Temporal activity data for sheep

(based on survey results and expert opinion)

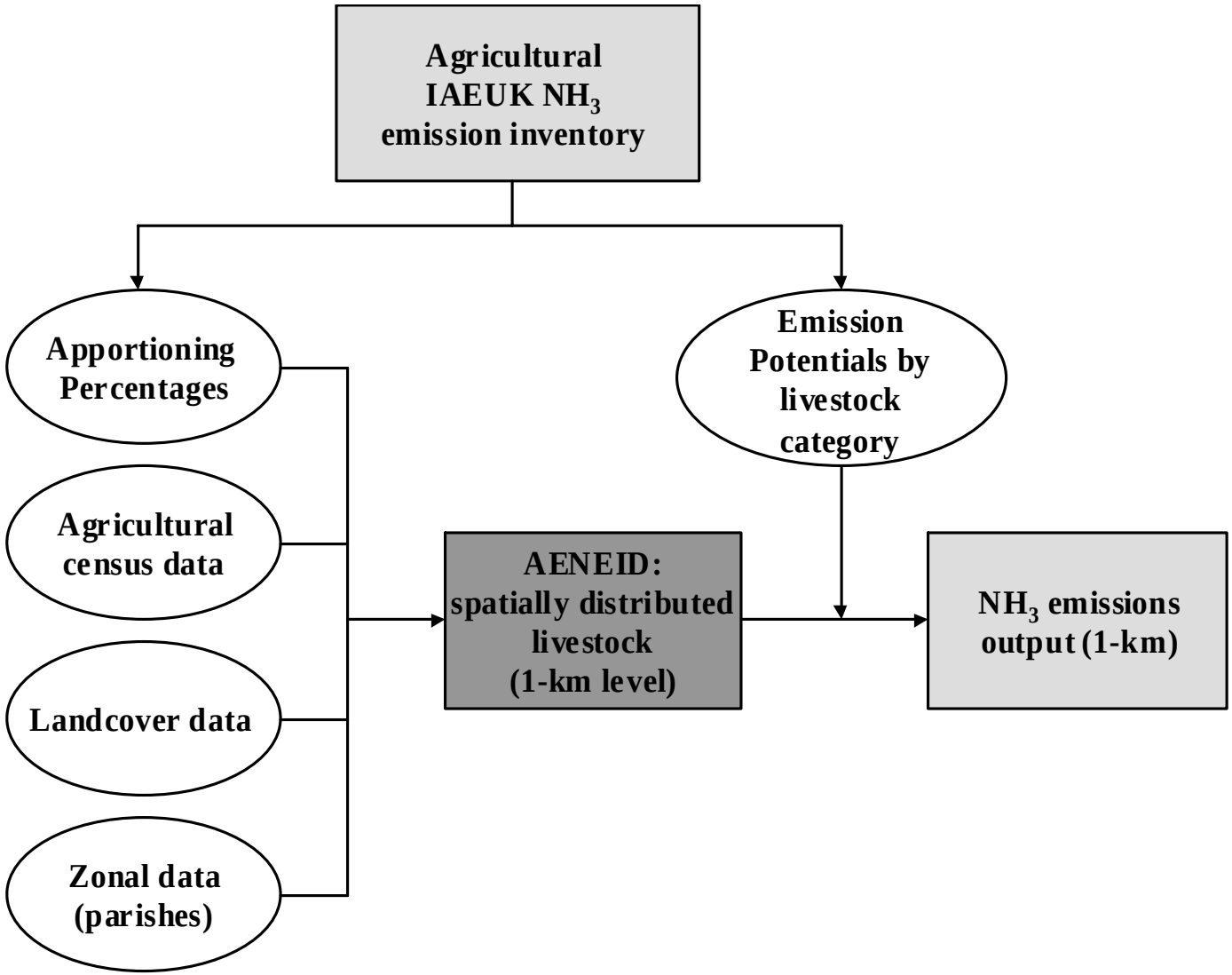
Sheep		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Grazing (d)	Upland sheep	31	28	31	30	31	30	31	31	30	31	30	31
	Upland lambs			31	30	31	30	31	30				
	Lowland sheep	31	18	21	20	31	30	31	31	30	31	30	31
	Lowland lambs	10	15	25	30	31	30	24	18				
Landspreading (%)	FYM							25 %	25 %	25 %	25 %		
Housing (d)	Sheep		10	10	10								
Storage (d)	FYM					30	30	30					

→ Monthly emission factors for sheep

The AENEID model

- Atmospheric Emissions for National Environmental Impacts Determination

The model distributes NH_3 emissions from a range of agricultural activities, such as grazing and housing of livestock, storage and spreading of manures, and fertilizer application, at a 1-km grid resolution over the most likely landcover types.



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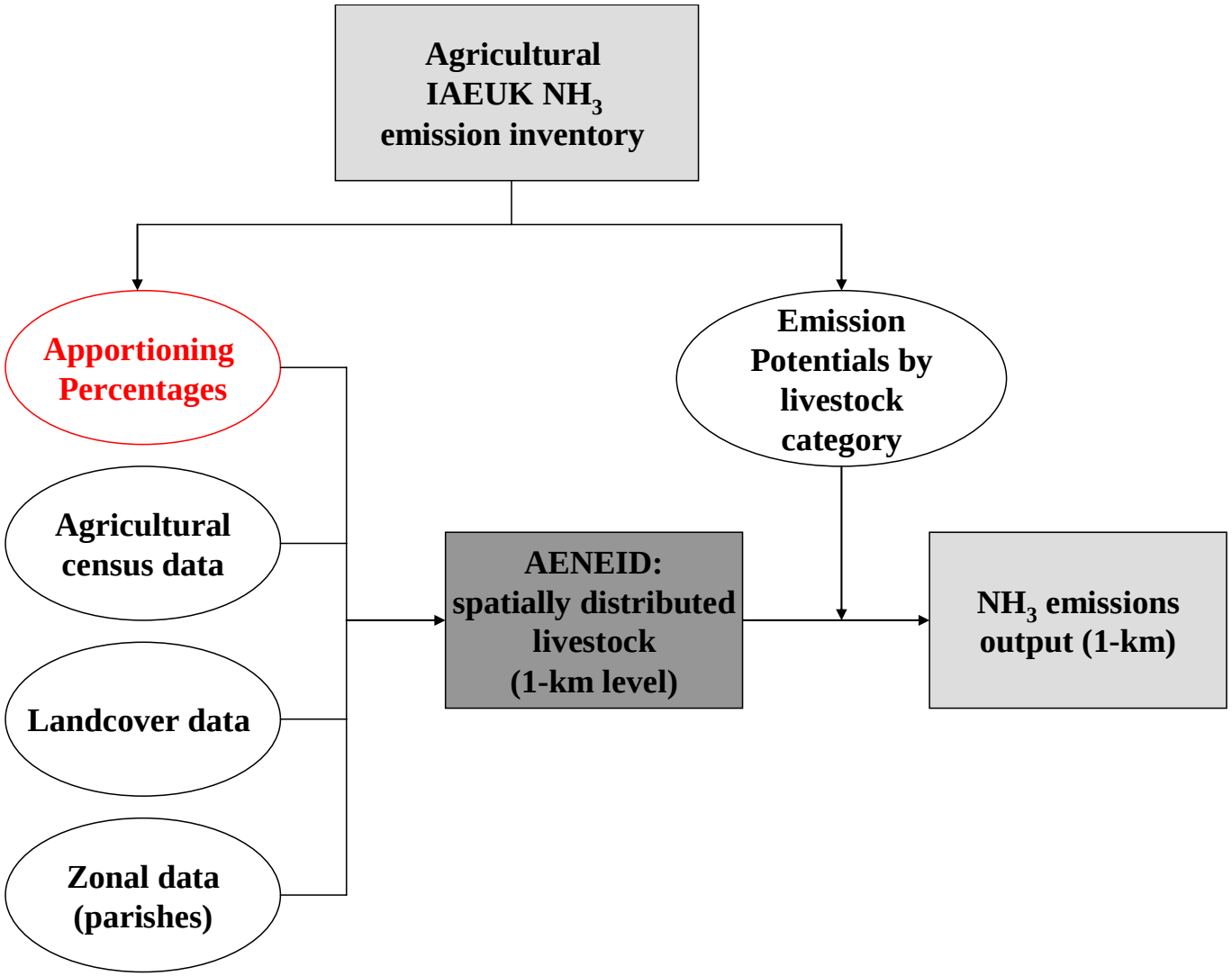

Calculating apportioning percentages (weights)

-AENEID approach (annual)

IAEUK (agricultural ammonia emission inventory) in the UK

Sheep

Total UK emission: 12.8 kt NH_3-N per year

Emission factor: 0.36 kg NH_3-N per sheep

Housing emissions	**1.5 kt NH_3-N**	**-->**	**12 %**
Manure storage emissions	**0.1 kt NH_3-N**	**-->**	**1 %**
Manure spreading emissions	**1.3 kt NH_3-N**	**-->**	**10 %**
Grazing emissions	**9.9 kt NH_3-N**	**-->**	**77 %**

Calculating apportioning percentages (weights)
-AENEID approach (annual)

Sheep

	Housing	Storage	Spreading	Grazing	Weight
Fraction of total NH_3 emission	**12 %**	**1 %**	**10 %**	**77 %**	
Improved pasture	(100 %)	(100 %)	(100 %)	(58 %)	
Partially improved pasture	(0 %)	(0 %)	(0 %)	(29 %)	
Poor grazing	(0 %)	(0 %)	(0 %)	(12 %)	
Very poor grazing	(0 %)	(0 %)	(0 %)	(2 %)	

Calculating apportioning percentages (weights)
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Very poor grazing	(0 %)	(0 %)	(0 %)	(2 %)	
Apportioned fraction of total NH_3 emission					
Improved pasture	12 %	1 %	10 %	45 %	**67 %**
Partially improved pasture	0 %	0 %	0 %	22 %	**22 %**
Poor grazing	0 %	0 %	0 %	9 %	**9 %**
Very poor grazing	0 %	0 %	0 %	1 %	**1 %**

Temporal activity data for sheep

(based on survey results and expert opinion)

Sheep		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Grazing (d)	Upland sheep	31	28	31	30	31	30	31	31	30	31	30	31
	Upland lambs			31	30	31	30	31	30				
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Landspreading (%)	FYM							25 %	25 %	25 %	25 %		
Housing (d)	Sheep		10	10	10								
Storage (d)	FYM					30	30	30					

→ **Monthly apportioning percentages for sheep**

Calculating apportioning percentages (weights)
-AENEID approach (December)

Sheep

	Housing	Storage	Spreading	Grazing	Weight
Fraction of total NH_3 emission	**0 %**	**0 %**	**0 %**	**100 %**	
Improved pasture	(100 %)	(100 %)	(100 %)	(58 %)	
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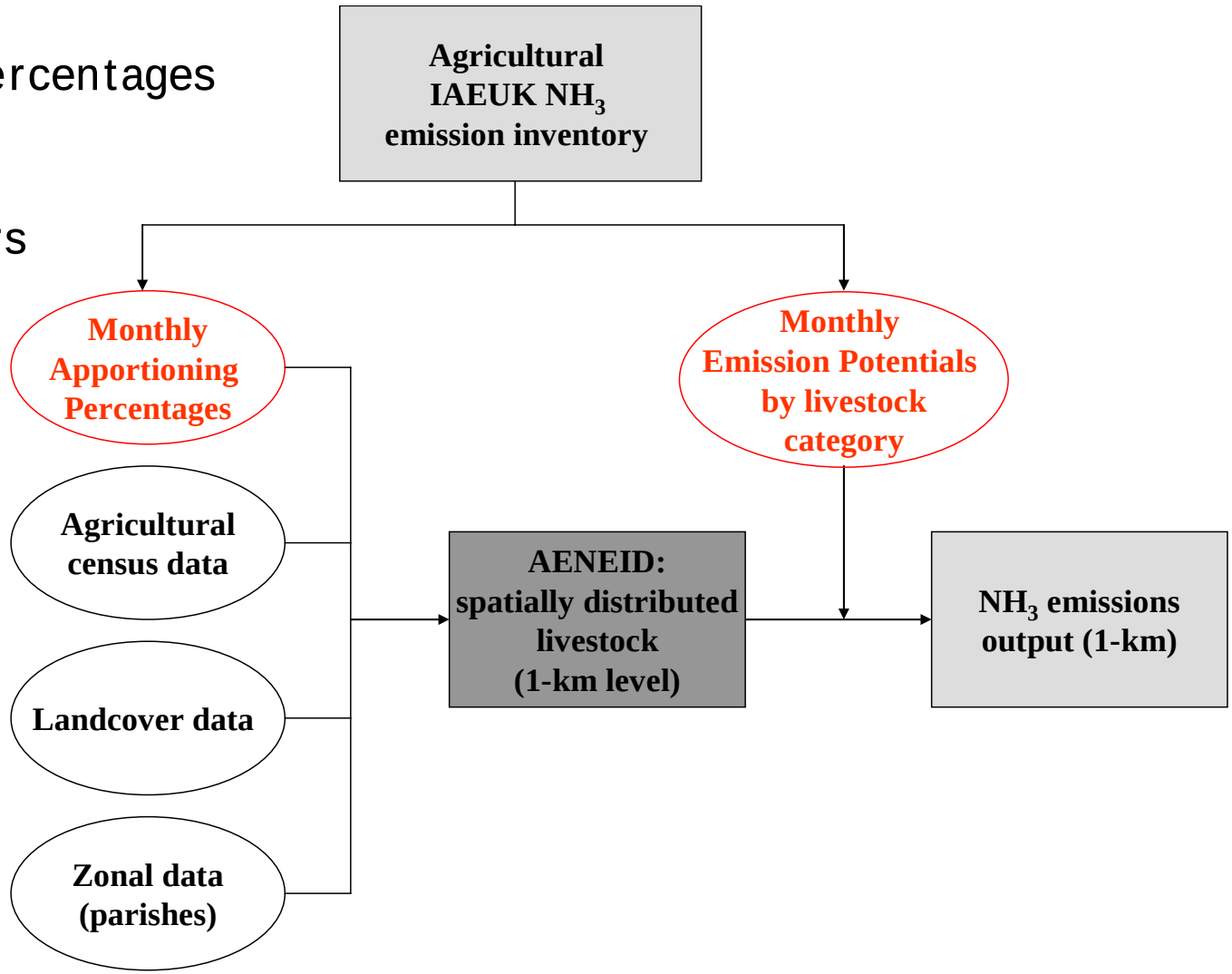
Apportioned fraction of total NH_3 emission

						(annual)
Improved pasture	0 %	0 %	0 %	58 %	**58 %**	**(67 %)**
Partially improved pasture	0 %	0 %	0 %	29 %	**29 %**	**(22 %)**
Poor grazing	0 %	0 %	0 %	12 %	**12 %**	**(9 %)**
Very poor grazing	0 %	0 %	0 %	2 %	**2 %**	**(1 %)**

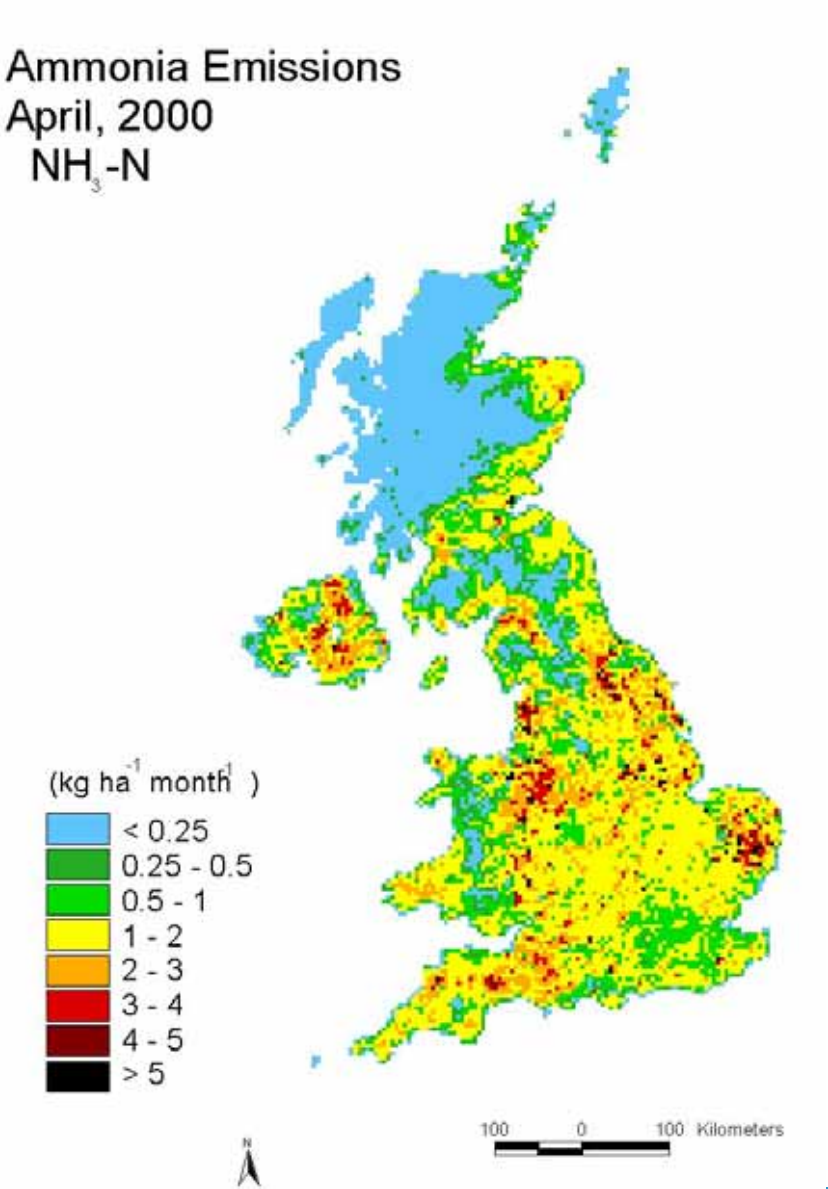
The monthly AENEID model

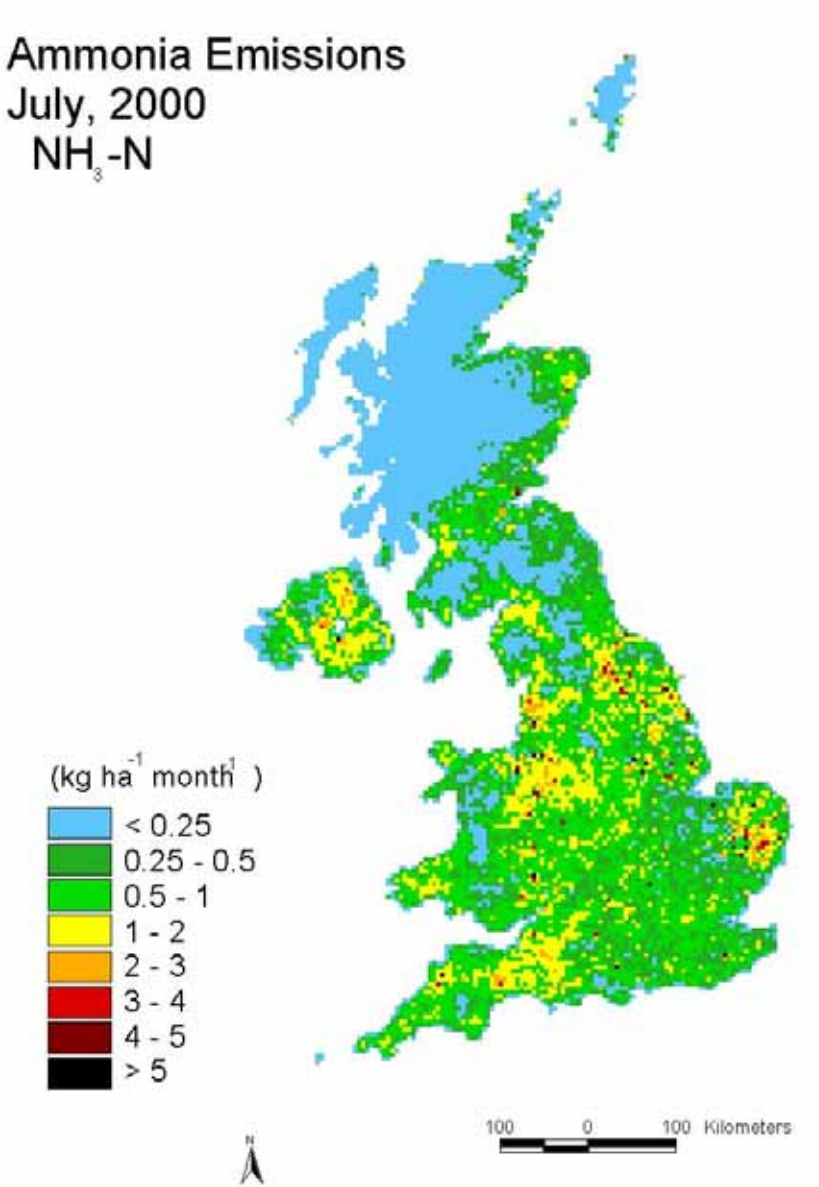
→ Monthly apportioning percentages (weights)

→ Monthly emission factors

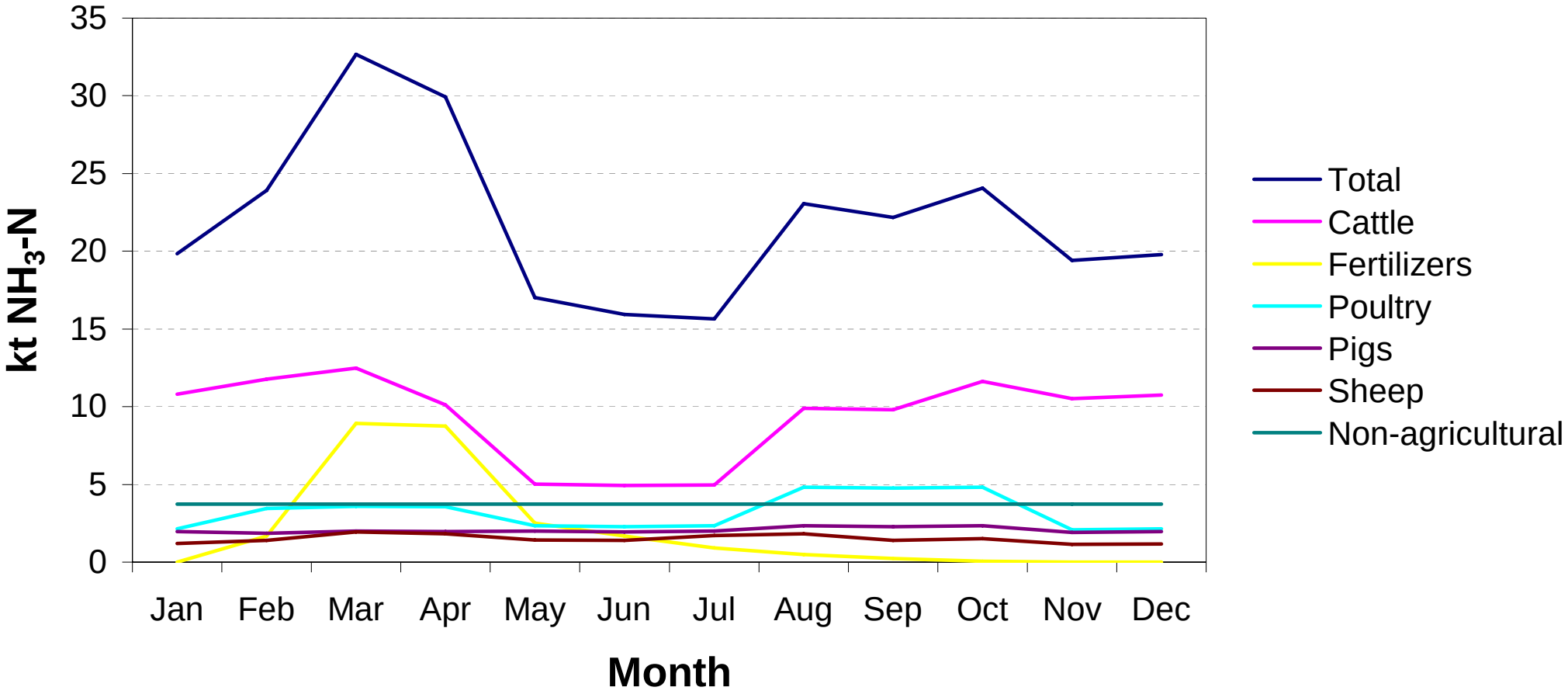


Results - Monthly emission maps





Monthly NH_3-N emissions, 2000



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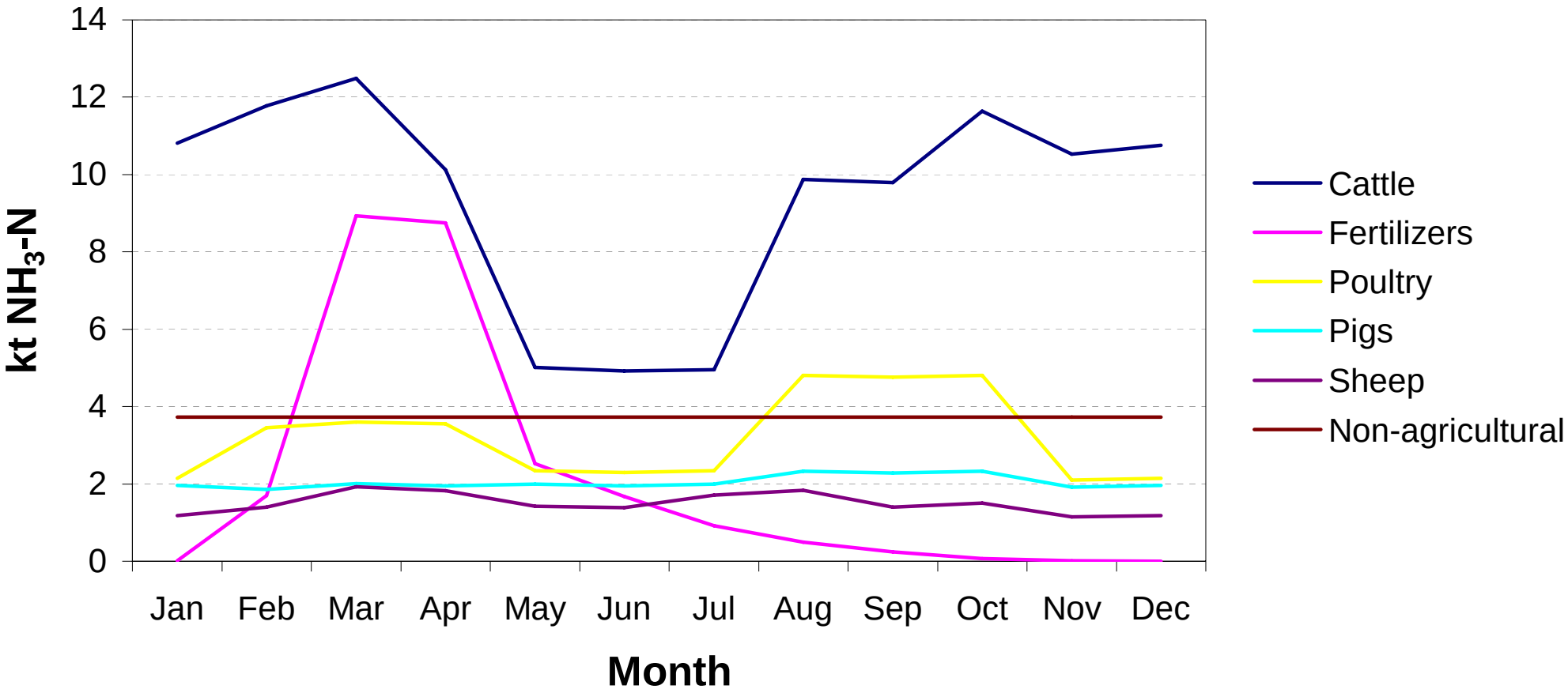
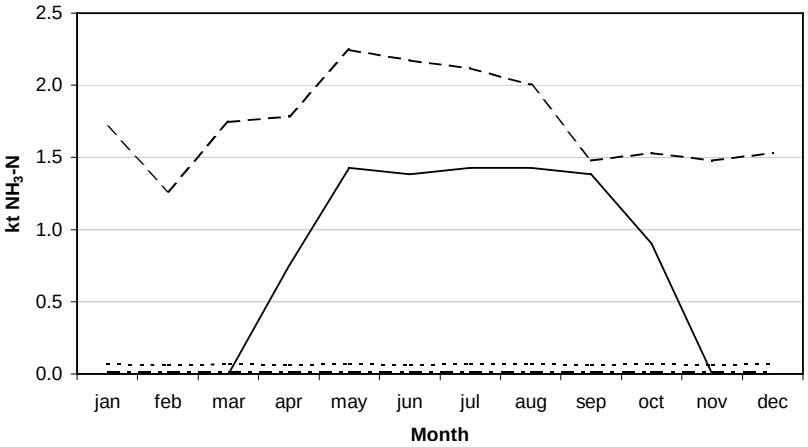
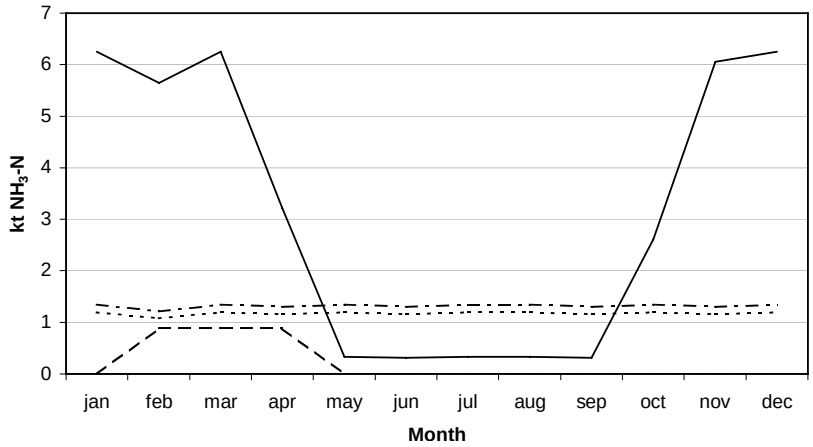


Seasonal variations associated with manure management stage

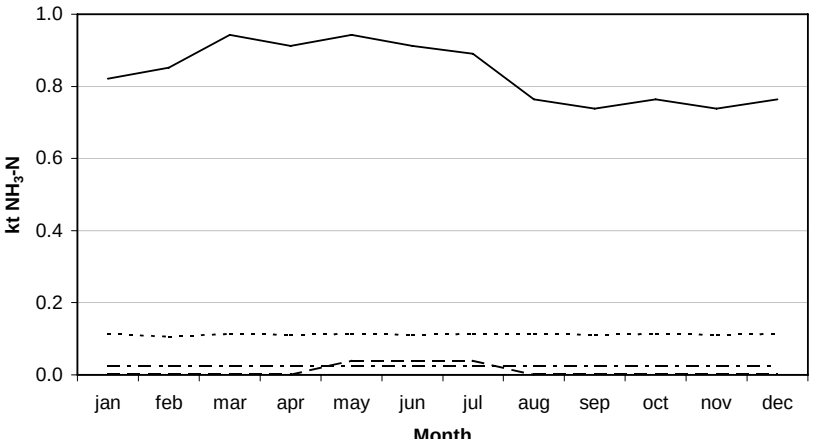
a) Grazing emissions



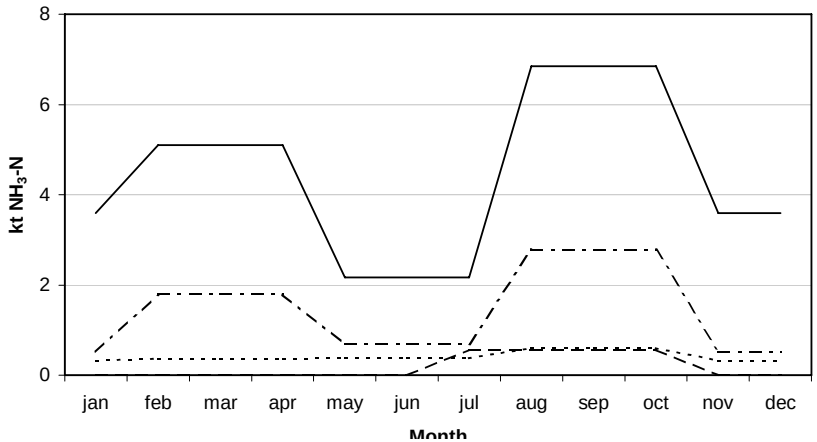
b) Housing emissions



c) Manure storage emissions



d) Manure spreading emissions



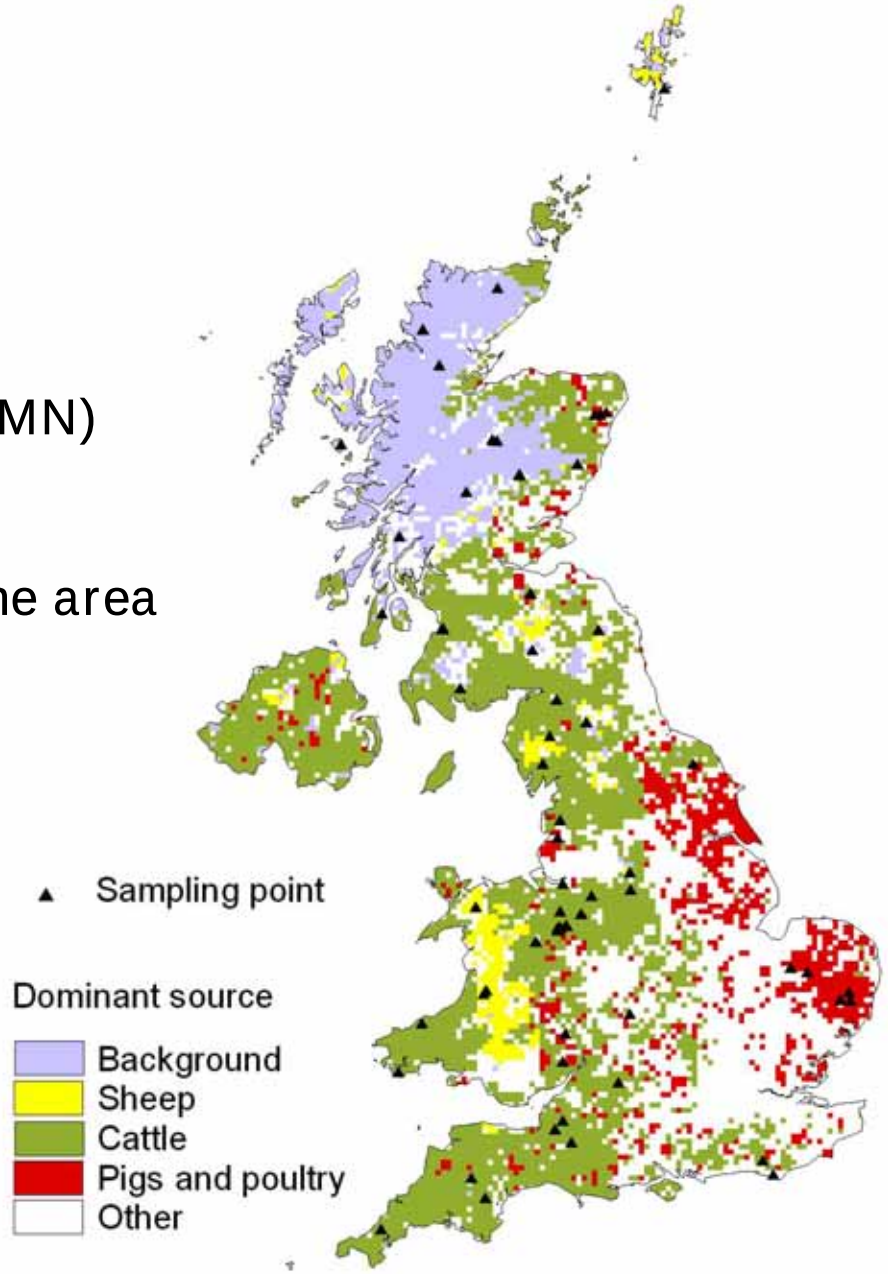
Cattle Sheep Pigs Poultry

Comparison with measurements

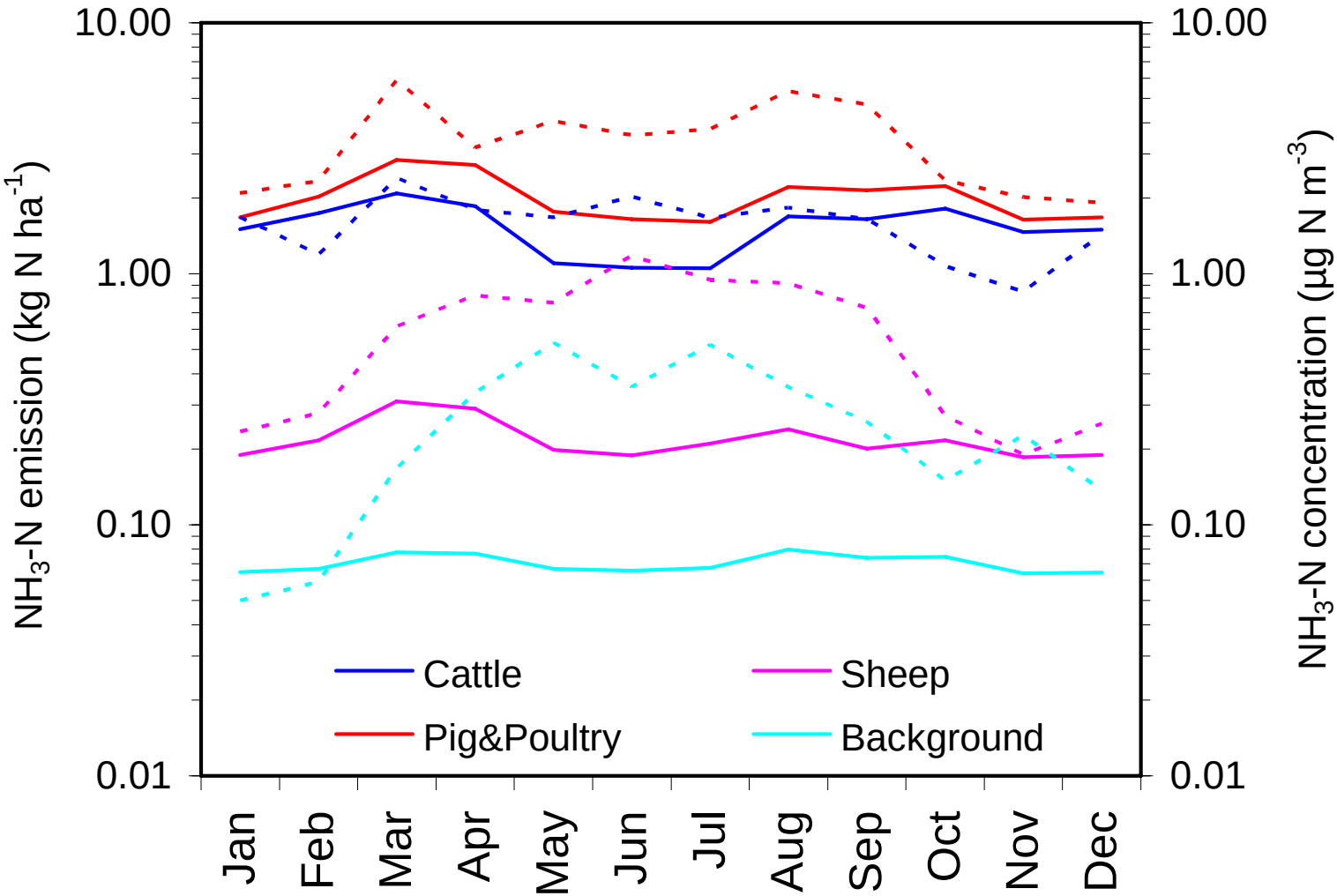
Concentration data from 83 sites in the UK National Ammonia Monitoring Network (NAMN)

Assigned into 4 different groups depending on the dominant NH_3 source in the area

1) Background
2) Sheep
3) Cattle
4) Pigs and poultry



Average modelled emission (kg N ha^{-1}) (——) and measured (µg N m^{-3}) (------)



Conclusions

The monthly AENEID model takes into account:

a) Temporal variation in the magnitude of the NH_3 emission (monthly emission factors)

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The seasonal variation was mainly influenced by:

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Future studies should concentrate on:

a) reducing uncertainties in the temporal activity data

b) develop approaches to include environmental factors such as temperature

Thank You!

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