Ammonia emissions from nitrogen fertilisers

- Nick Hutchings & Maarit Mäenpää (Aarhus University, DK)
- Andreas Pacholski & Roland Fuß (Thünen Institute, DE)
- Sebastian Wulf & Julia Jaquemotte* (KTBL, DE) (*now ZALF)
- Data collation (global and all years)
  - Includes data collated earlier by Aarhus University and others
- Statistical analysis by Aarhus University

Data collated from a range of experiments

- Data from laboratory and field experiments
  - Greater control and more variables in laboratory experiments
  - Greater realism in the field
- Dataset is unbalanced
  - Not all variables were measured in all experiments
  - Few data for some fertilizers
- Group fertilizers into classes
  - Increase the basis for statistical analysis ☺
  - Increase the stability of emission factors ☺
  - Lose distinction between individual fertilizers ☹

Fertiliser classes

Fertiliser class	Fertiliser	N	% use
Urea++	urea	1264	
	urea phosphate	36	
	double urea phosphate	11	
	urea ammonium sulphate	20	
	total	**1331**	**20**
UAN	urea ammonium nitrate	**132**	**13**
Ammonium+1	ammonium bicarbonate	22	
	ammonium sulphate	209	
	diammonium phosphate	25	
	monoammonium phosphate	3	
	total	**259**	**23**
Ammonium+2	ammonium nitrate	176	
	calcium ammonium nitrate	76	
	total	**252**	**43**

Measurement method, place & application

Measurement method	N
Micromet.	191
15N	6
Closed chamber	467
Drager-Tube	119
Semi-open chamber	117
Ventilated chamber	825
Wind tunnel	249

- Laboratory (N=709), field (N=1265)
- Broadcast (N=1635), incorporated (N=329), injected (N=10)

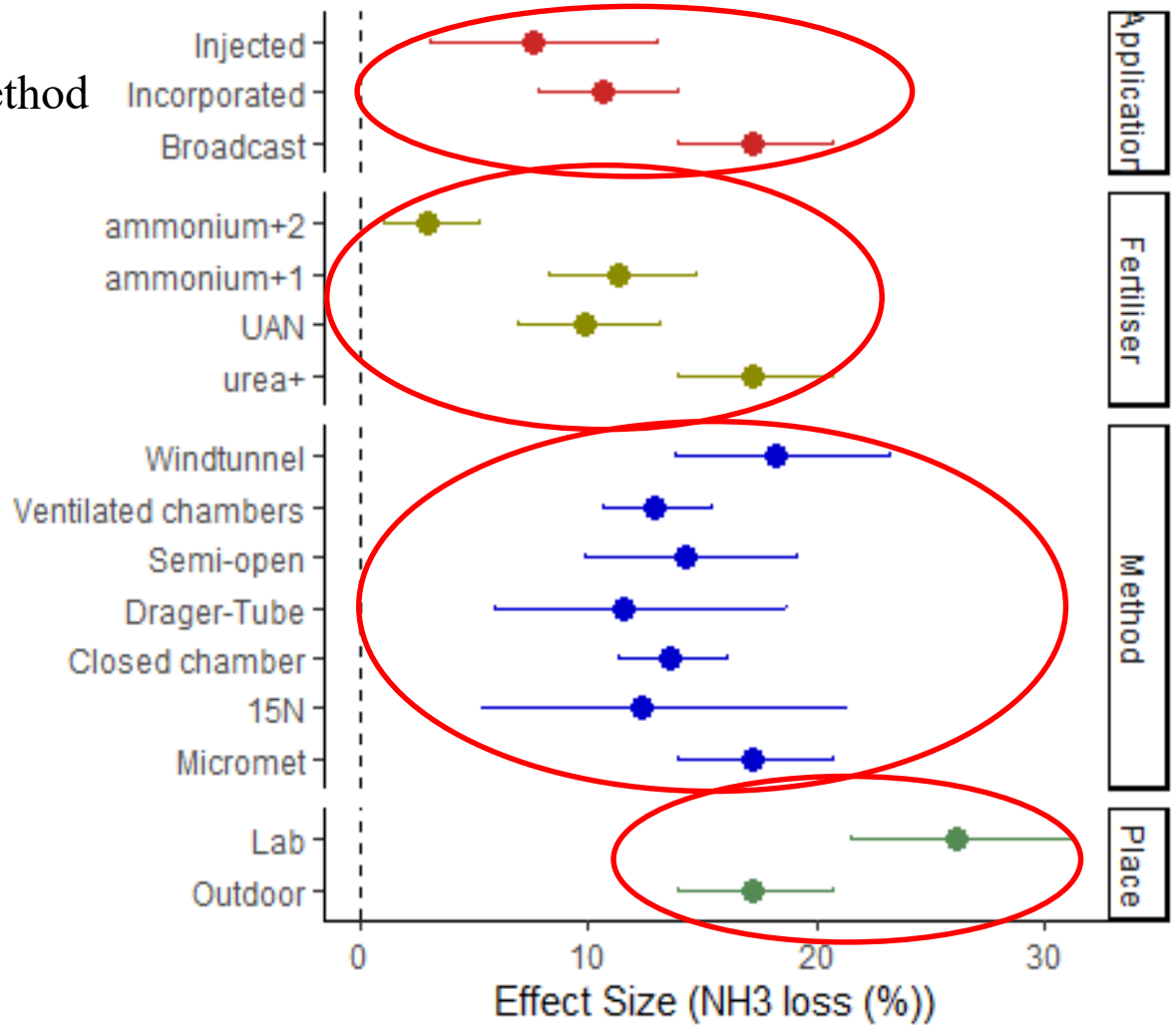
Model 1

Application method

Fertiliser class

Measurement method

Place



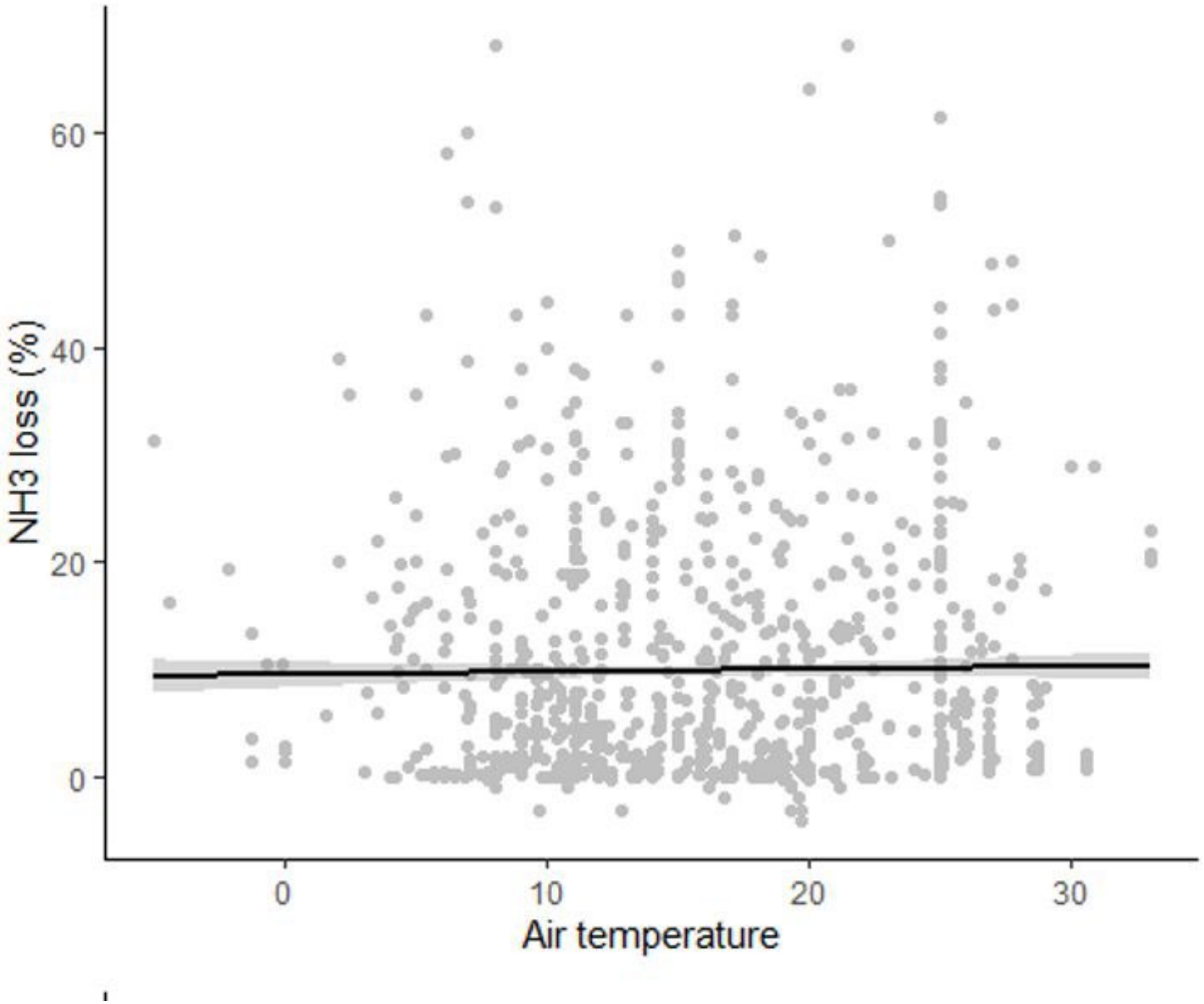
Effect of soil pH – model 2

- No statistically significant effect of soil pH:
  - Emission for soil pH >7.0 (“chalky”) similar to <7.0 (“normal”)
- Statistically significant interaction between fertiliser class and soil pH:
  - No effect of soil pH on urea+ class
  - Significant effect of soil pH on UAN, Ammonium+1 and Ammonium+2

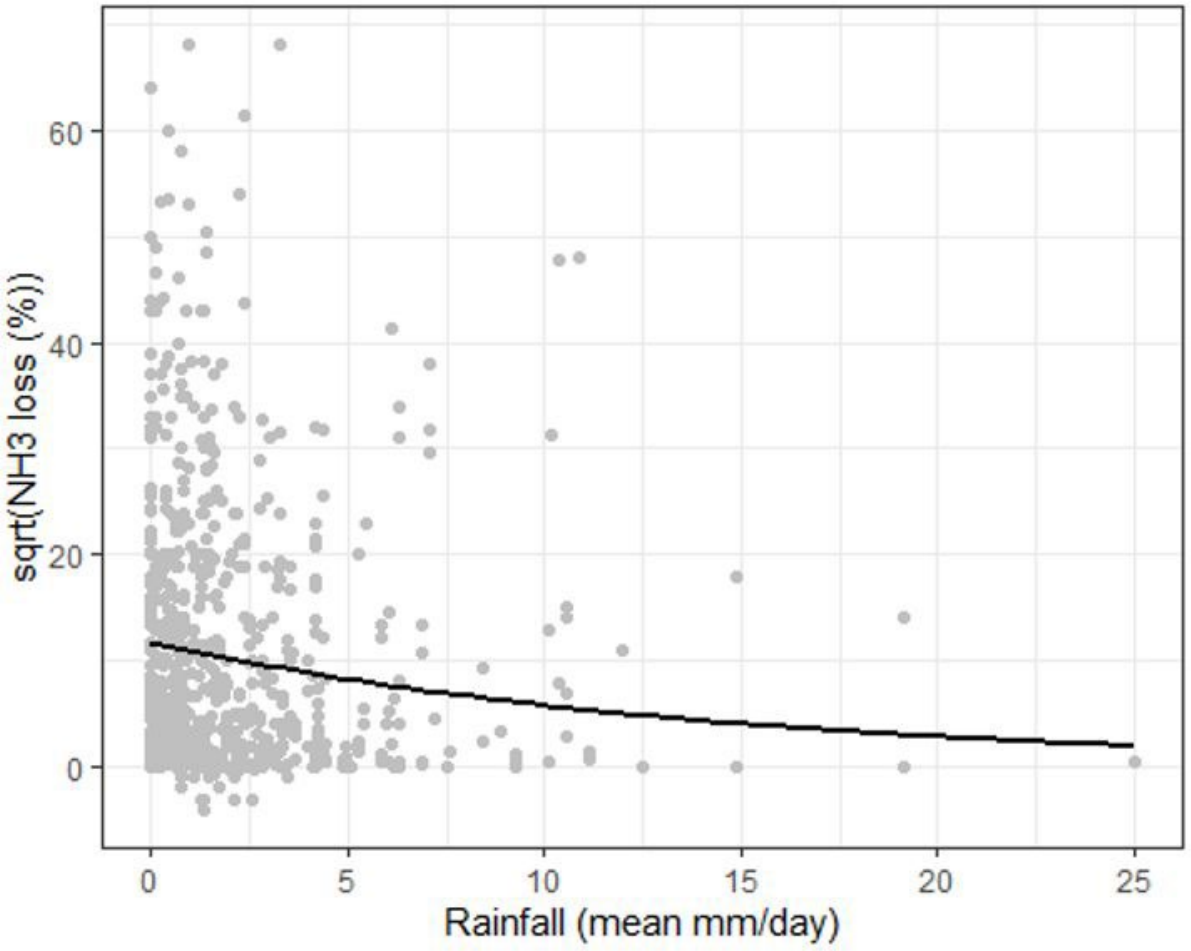
Weather variables

- Statistically significant linear effect of air temperature
  - But the slope of the regression was low
- No statistically significant effect of mean rainfall
  - But a statistically significant effect of an exponential function
- Combine linear effect of temperature and exponential effect of rainfall
  - Both effects are significant

Effect of air temperature



Non-linear effect of rainfall



Other variables

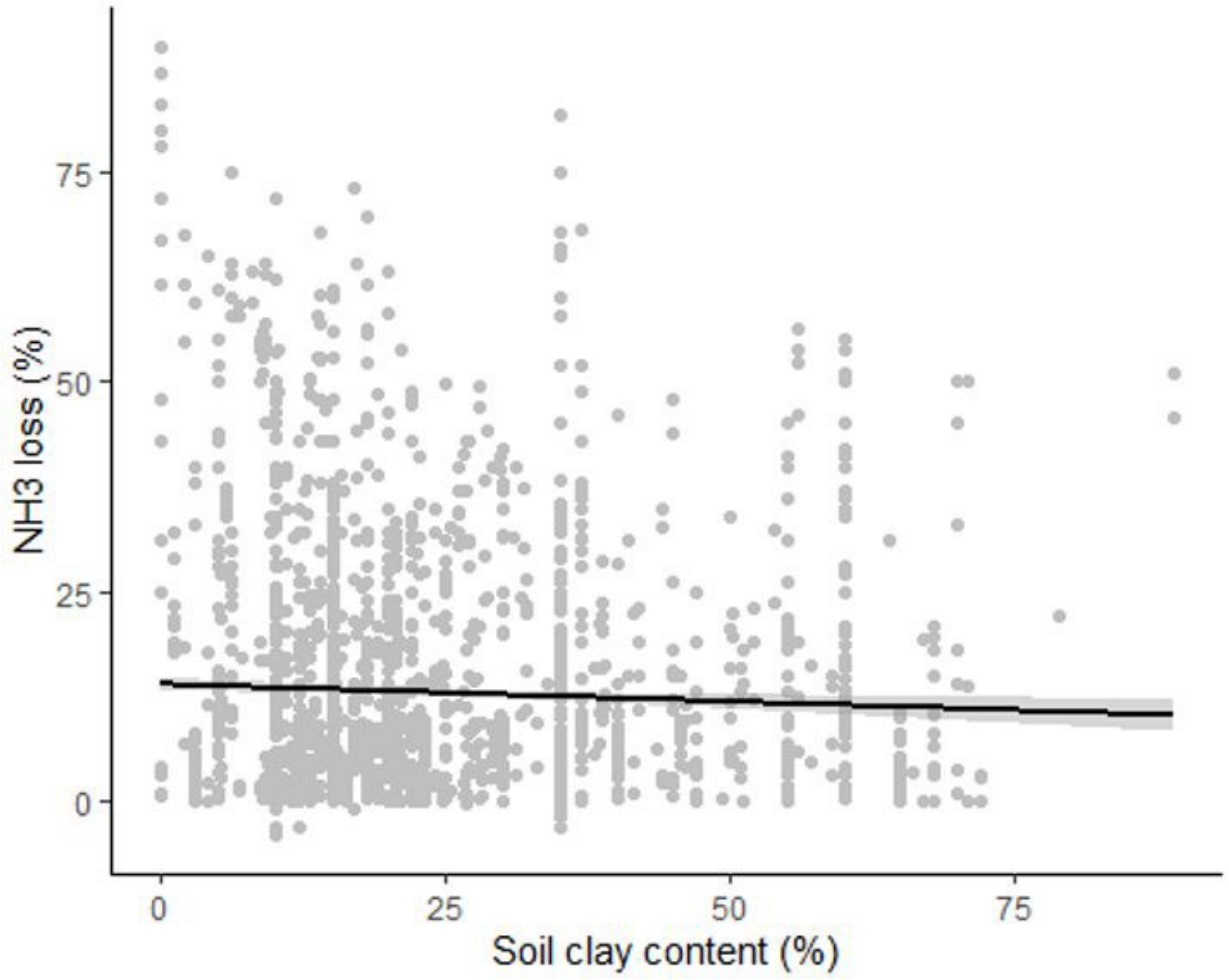
- Other statistically significant variables
  - Clay concentration in the soil
- Non-statistically significant variables
  - Application rate
  - Soil organic carbon concentration
  - Field cover (bare soil, arable, grassland)

AARHUS UNIVERSITY

ATB Leibniz-Institut für Agrartechnik Potsdam-Bornim e.V.

UNIWERSYTET ZIELONOGÓRSKI

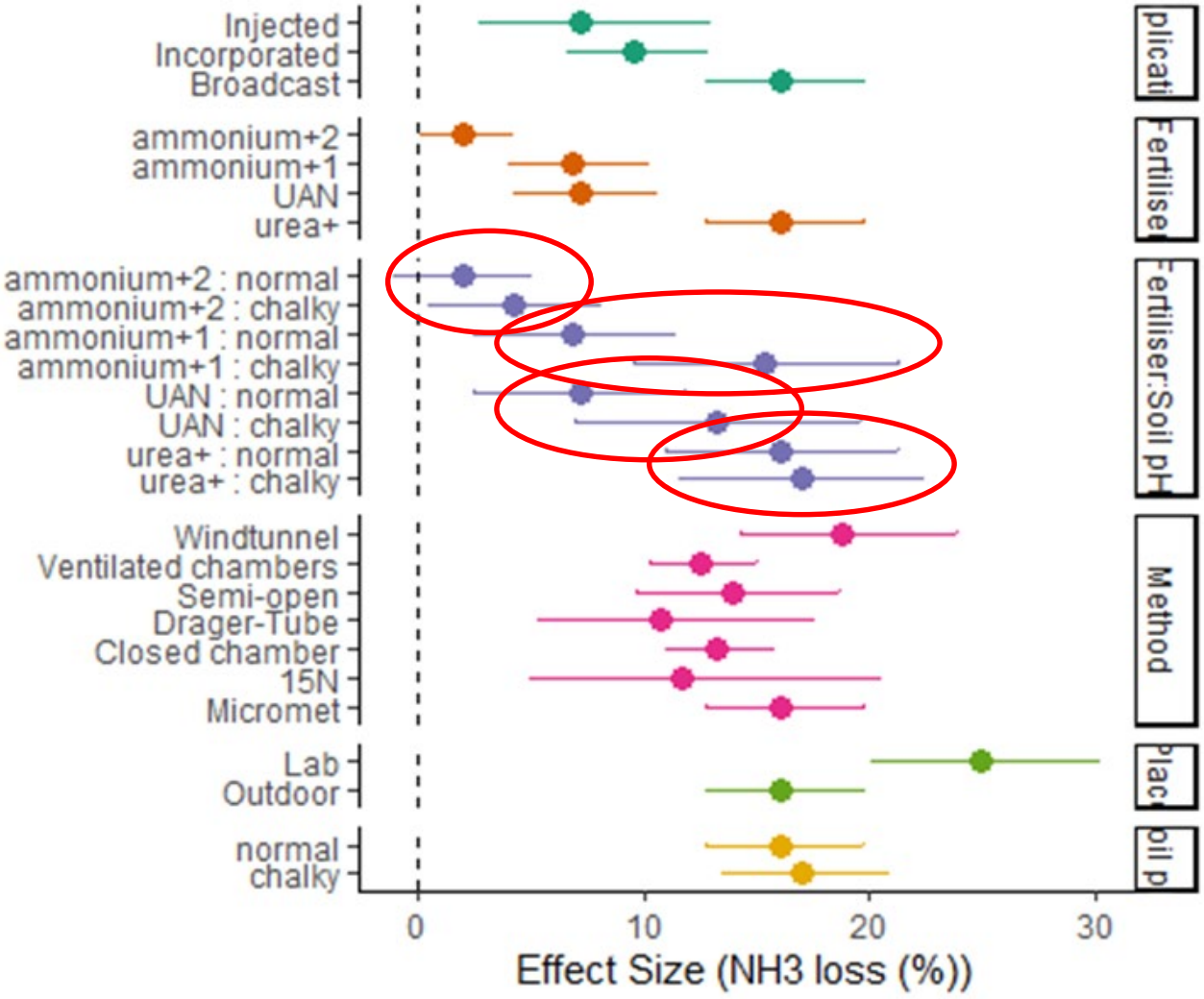
Effect of clay concentration



Use combination of Model 1 & 2

- Variables have a major effect
- Most readily accessible and accurate data
- Parameterise for ‘gold standard’ situation
  - Field experiments
  - Micrometeorology measurement method
  - Broadcast application

Combining Model 1 and 2



Choice of model for use in Guidebook

- Fertiliser class and soil pH (normal v chalky)
  - Strong effects + accessibility of data
- Do not include
  - Clay concentration, air temperature - small effect
  - Non-linear effect of rainfall – data not readily accessible
- Scope for Tier 3 models
  - Clay concentration, air temperature, non-linear rainfall
  - If Parties can provide good-quality input data

Anhydrous ammonia

- Very few data
  - Mainly old, mainly from USA
- Anhydrous ammonia is applied by injection
  - Expect low emissions, if knife injected into tilled soil
  - Disc injectors used on no-till soil – can expect higher emissions
- EF unchanged (await new data)

Estimating emission factors is difficult

- Distribution of fertilizer use in Europe ≠ distribution of measurement data
  - 43% of N applied as low-emission fertilizers
  - 13% of measurement data from low-emission fertilizers
- Emission data contains substantial unexplained variation
  - Leads to uncertainty concerning emission factors
  - Percentage uncertainty in EF for low-emission fertilisers will be high

Generally higher emission factors than Guidebook 2019

	Norm pH		Chalky	
	Ave old	New	Ave old	New
	g NH_3 (kg N applied)$^{-1}$			
Anhydrous ammonia	21	21	39	39
Ammonium nitrate	17	24	35	52
Ammonium phosphate	55	84	101	187
Ammonium sulphate	99	84	182	187
Calcium ammonium nitrate	9	24	18	52
NK mixtures	19	24	35	52
NPK mixtures	60	84	101	187
NP mixtures	60	84	101	187
N solutions	108	87	105	161
Other straight N compounds	12	0	12	0
Urea	171	195	181	206

Changes compared to Guidebook 2019

- Generally higher EFs
  - Percentage change greatest for low-emission fertilizers
- Few abatement measures for non-urea based fertilizers
- Strong incentive to use Tier 3 methodologies
  - Account for temperature and rainfall
- Need for more and better emission data for low-emission fertilizers