

Higher Tier methods for ammonia emission from mineral fertilizers

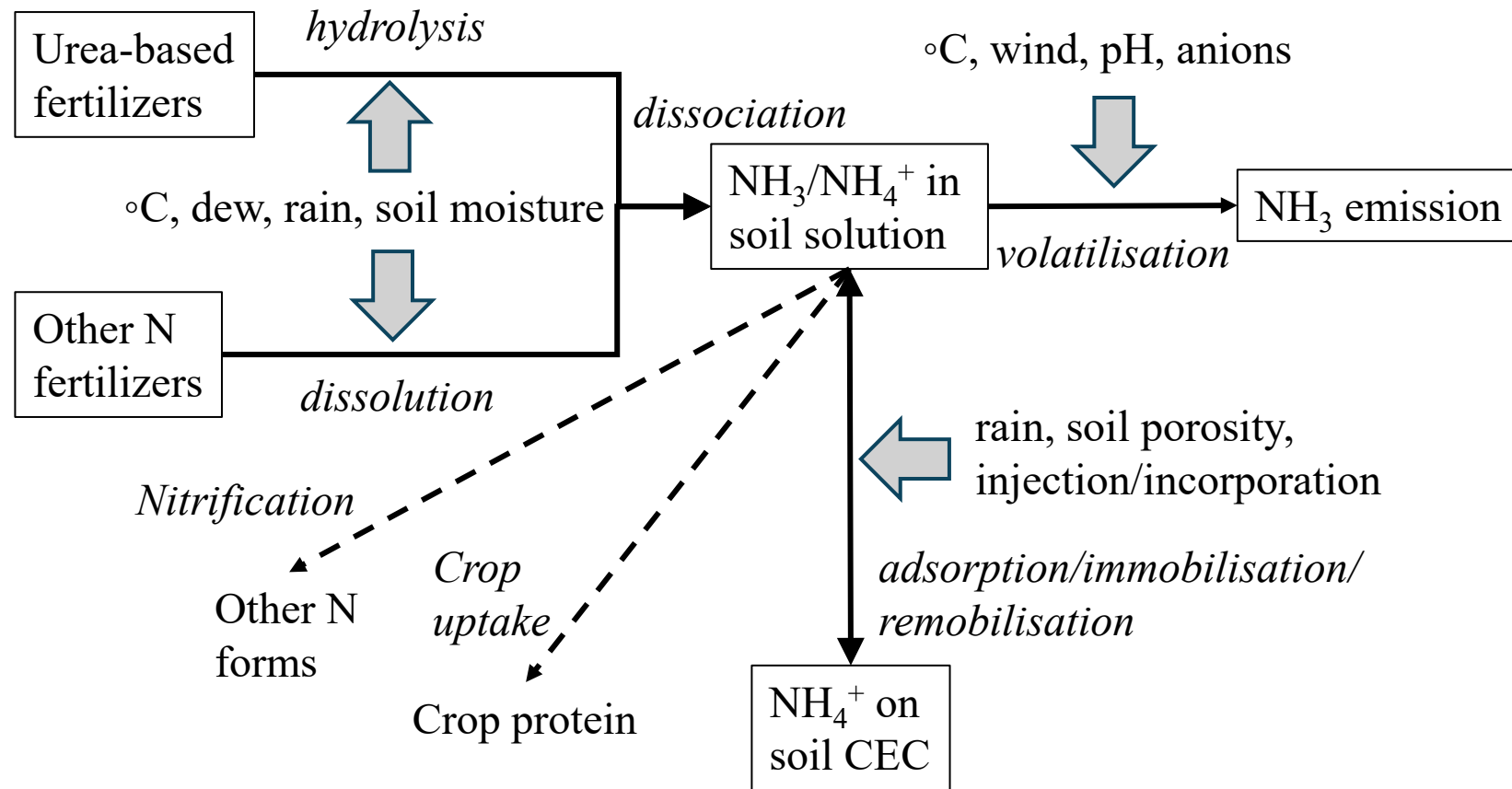
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New publication

- Higher tier estimation of ammonia emissions from synthetic nitrogen fertilizers in emission inventories: data collation, methodology and analysis
- N.J. Hutchings, J. Schoof, M. Mäenpää, A. Pacholski, J. Webb, R. Albrechtsen
- <https://doi.org/10.1016/j.jclepro.2025.147438>
- Open access

Ammonia emission is complicated...



Data collation

- Location (indoor versus outdoor)
- Measurement method (ventilated-, closed-, semi-open chambers, Dräger Tube Method, wind tunnel, micrometeorological)
- Application method (broadcast, incorporated, injected)
- Fertilizer application rate
- Soil pH (≤ 7.0 , > 7.0)
- Soil clay content
- Air temperature
- Rainfall intensity

Statistical Approach

- Base model (fertilizer category, measurement method, application technique, soil pH, fertilizer category x soil pH)
- Explored additional effects of application rate, clay content, mean air temperature, rainfall intensity, mean air temperature x rainfall intensity
- Models
 - A = all data, LO = outdoor data only
 - A1 & LO1 = base model variables
 - Ax & LOx = base model + additional variables
- Only models with statistically-significant effects ($p < 0.05$) shown

Variable	All data			
	Model			
	A1	A2	A3	A4
Fertilizer category	***	***	***	***
Application technique	***	***	***	***
Measurement method	***	***	***	***
Indoor/outdoor	***	***	***	***
Soil pH	***	***	***	***
Soil pH x Fertilizer category	***	***	***	***
Application rate				
Clay content		***		***
Mean air temperature			***	***
Mean rainfall				
Rainfall x air temperature				
Number of obs.	2500	2295	1855	1693
Marginal R ² (%)	23.5	25.2	24.6	27.0
Conditional R ² (%)	50.3	53.5	51.4	54.8
AICc	7610	6919	5611	5079
RMSE	1.04	1.01	1.02	1.00

Variable	Outdoor only			
	Model			
	LO1	LO2	LO3	LO4
Fertilizer category	***	***	***	***
Application technique	***	***	***	***
Measurement method	**	***	***	***
Indoor/outdoor	NR	NR	NR	NR
Soil pH	***	***	***	***
Soil pH x Fertilizer category	***	***	***	***
Application rate		***		***
Clay content				
Mean air temperature		***	***	*
Mean rainfall				*
Rainfall x air temperature				NS
Number of obs.	1355	1317	1034	1025
Marginal R ² (%)	18.2	19.0	19.9	20.9
Conditional R ² (%)	43.8	45.7	45.0	47.6
AICc	7647	6084	5626	5612
RMSE	1.045	1.02	1.03	1.02

Revised Tier 2 emission factors

- Based on model LO1:
 - Outdoor experiments
 - Micrometeorological measurement method
 - Broadcast application
- Emission factors vary depending only on:
 - Fertilizer type
 - Soil pH

Tier 2 - comparison with Guidebook 2023

	pH≤7		pH>7	
	New	GB2023	New	GB2023
	gNH ₃ /kg N applied			
Urea	189	195	180	206
UAN	101	87	159	161
Ammonium+1*	48	84	199	187
Ammonium+2**	36	24	53	52

Red = increased EF
Blue = reduced EF

* e.g. Ammonium sulphate, Monoammonium phosphate

** Ammonium nitrate, Calcium ammonium nitrate

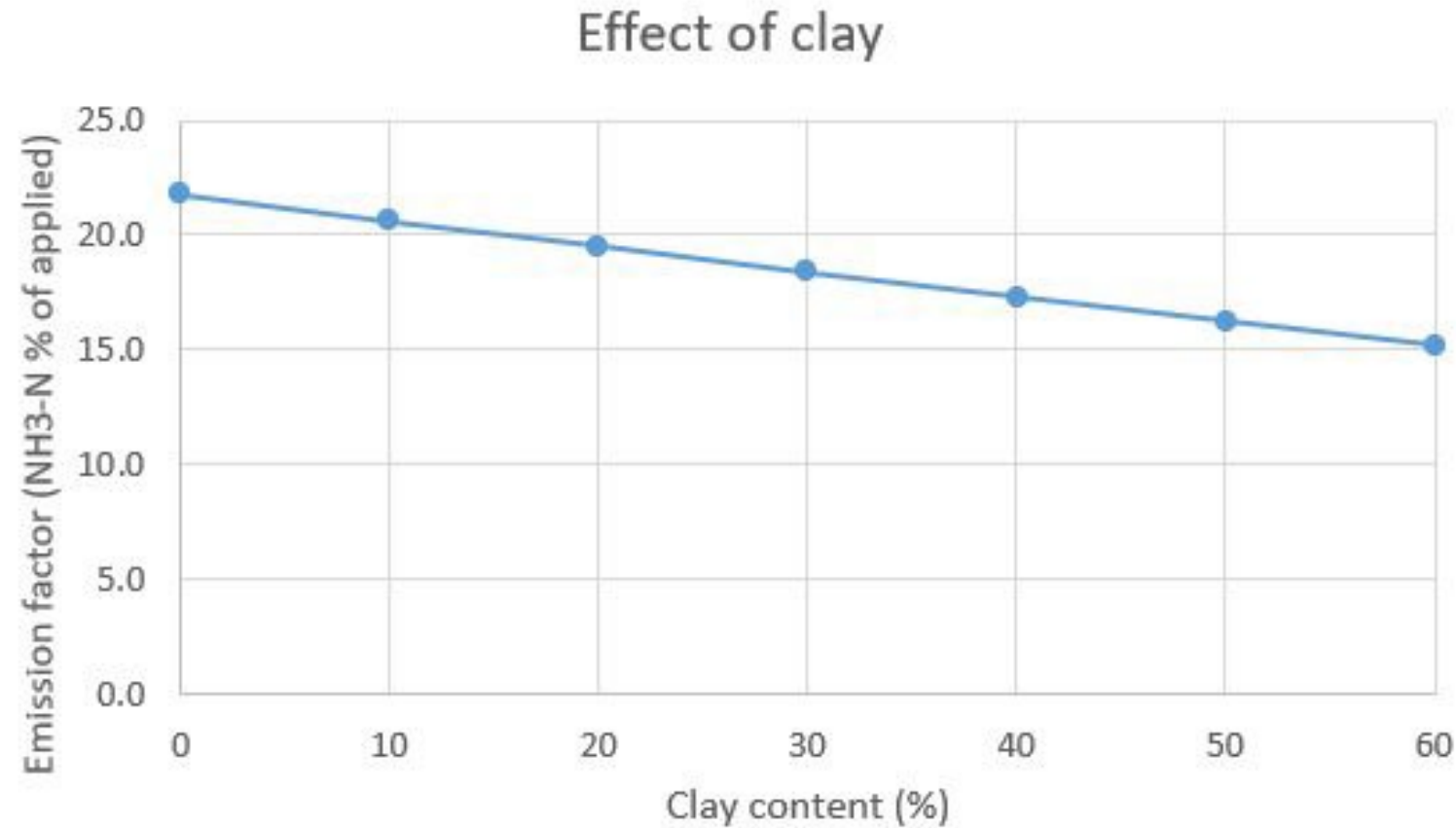
Tier 3 methodologies

- Opportunities to take account of additional variables
 - Clay content
 - Air temperature
 - Rainfall intensity
 - Fertiliser application rate
- Not all variables can be combined in one model
 - Too few data
 - Too much statistical noise

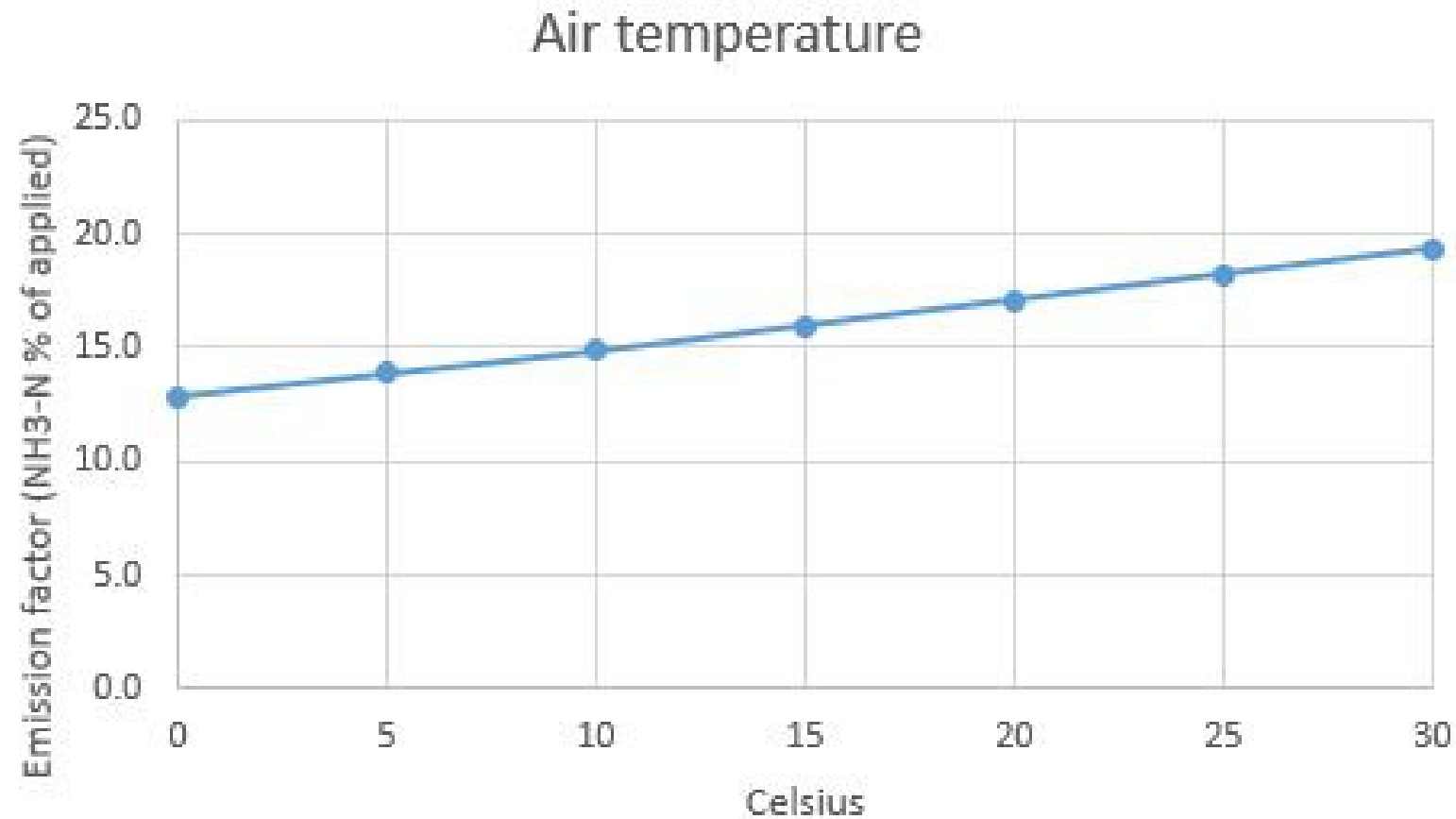
Move to Tier 3?

- Would it significantly improve accuracy?
- Can you obtain the input variables?
 - With sufficient accuracy
 - At a reasonable cost

Example: effect of clay content on urea



Example: effect of air temperature on urea



Access to variables

- Example 1: include clay content
 - Need maps of clay content
 - Need to know how much of each fertilizer is applied to each soil type
- Example 2: include air temperature
 - Need to know when and where each fertilizer is applied
 - Monthly/seasonal data is adequate (farm survey)
 - Weather data is generally available

Move to Tier 3?

- Yes, if the necessary data are available
 - More accurate
- For Europe, will result in lower emission factors
 - Moving from Tier 2 to 3 is not abatement, just less bias
- New version of the Ammonia Guidance Document in preparation
 - Revised information on abatement technologies



Questions?