An update of emission factors for Nitric Oxide emissions from croplands and grasslands

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Why Update NO Emission Factors?

Current EMEP/EEA Tier 1 EF (Chapter 3D):

0.0133 (0.0015 – 0.0317) kg NO–N (kg N)$^{-1}$

(Stehfest & Bouwman, 2006; unchanged since EMEP/EEA Guidebook 2006)

Key issues with the current EF:

- Wide uncertainty range
- No distinction between synthetic and organic fertilisers
- No climate or crop-type stratification
- Skiba et al. (2021): data still insufficient for revision

Tier 1 default EFs						
	Code	Name				
NFR Source Category	3.D	Inorganic N fertilisers, sewage sludge, other organic fertilisers, cultivated crops, crop residues and farm-level agricultural operations including storage, handling and transport of agricultural product				
Fuel	NA					
Not applicable						
Not estimated						
Pollutant	**Value**	**Unit**	**95 % confidence interval**		**Reference**	**NFR Code**
			Lower	**Upper**		
NH_3 from N fertiliser	0.085	kg NH_3 kg^{-1} fertiliser N applied	NC	NC	See Annex 1 1.2	3Da1
NH_3 from livestock manure applied or deposited to soil	See Tables 3.2 and 3.9 in Chapter 3B					3Da2a, 3Da3
NH_3 from sewage sludge	0.0066 or 0.13	kg NH_3 $capita^{-1}$ kg NH_3 (kg N applied)$^{-1}$	NC	NC	See Annex 1 (A1.1.2)	3Da2b
NH_3 emission from Other organic wastes	0.08	kg NH_3 (kg waste N applied)$^{-1}$	NC	NC	Method for fertiliser applications	3Da2c
NH_3 emission from crop residues	0.034	kg NH_3 kg^{-1} crop N residue N on soil surface for > 3 days	NC	NC	de Ruijter and Huismans (2019)	3Da4
NO from N applied in fertiliser, manure and excreta (*)	0.04	kg NO_2 kg^{-1} fertiliser and manure N applied	0.005	0.104	Skiba et al (2021)	3Da1 (fertiliser), 3Da2a (manure), 3Da3 (excreta)
NO from sewage sludge (*)	0.002	kg NO_2 $capita^{-1}$	NC	NC	See Annex 2 (A2.3)	3Da2b
NO emission from other organic wastes (*)	0.04	kg NO_2 kg^{-1} waste N applied	0.005	0.104	Skiba et al (2021)	3Da2c

Data for Meta-Analysis

Excluded:

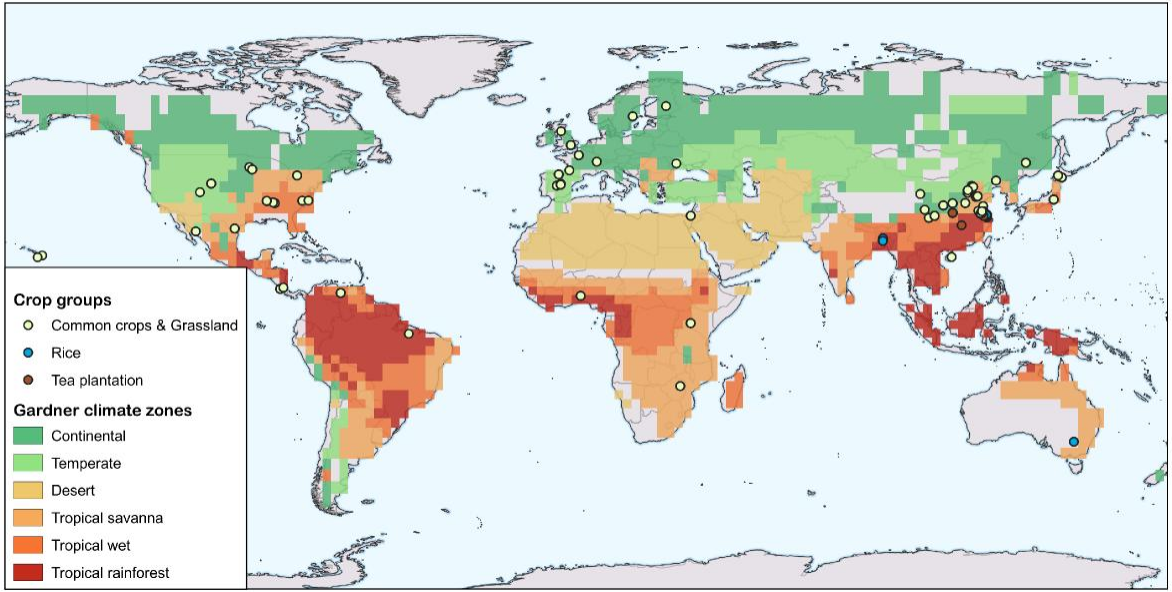
•Greenhouse and laboratory experiments

•Biochar treatments

•Nitrogen inhibitors and slow-release fertiliser applications

•Studies with legumes

•Experiments less than 14 days



Final Data:

- 692 observations from 128 studies (1976 – 2020)
- Global coverage across 6 climate zones
- Split into 3 datasets: **Common crops/grassland** (611), **Rice** (50), **Tea** (32)

Statistical Approach

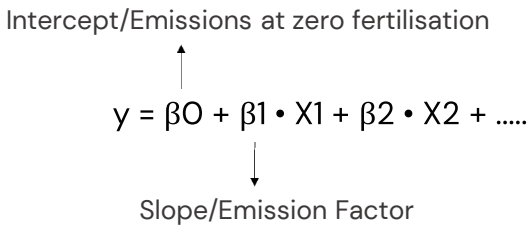
Bayesian Generalised Linear Mixed Model (GLMM)

- Combines prior knowledge (EMEP/EEA defaults) with compiled field measurements
- Produces posterior distributions with credible intervals — direct probability statements about the true EF

Handling skewed emissions data:

- Gamma distribution (handles positive skewness without log-transformation)
- Identity link (preserves linearity for direct inventory application)
- Random intercepts by location (accounts for spatial clustering of studies)

Parametric model:



Model results: Global Emission Factor

Parameters		Estimate	Credible interval	
			2.5%	97.5%
Emission at zero fertilisation (kg NO-N ha^{-1} yr^{-1})		**0.5224**	0.3168	0.8396
Emission factor (kg NO-N ha^{-1} / kg $N_{applied}$ ha^{-1})	**Synthetic N input**	**0.0042**	0.0035	0.0049
	Organic N input	**0.0003**	-0.0003	0.0009
Length of experiment (Longer experiments = higher cum. Emissions) kg NO-N ha^{-1} / day		**-0.0002**	-0.0006	0.0001

Model results: Climate/Crop Stratification

Emission factor for Synthetic N input : (% of NO-N emitted / kg $N_{applied}$ ha^{-1})

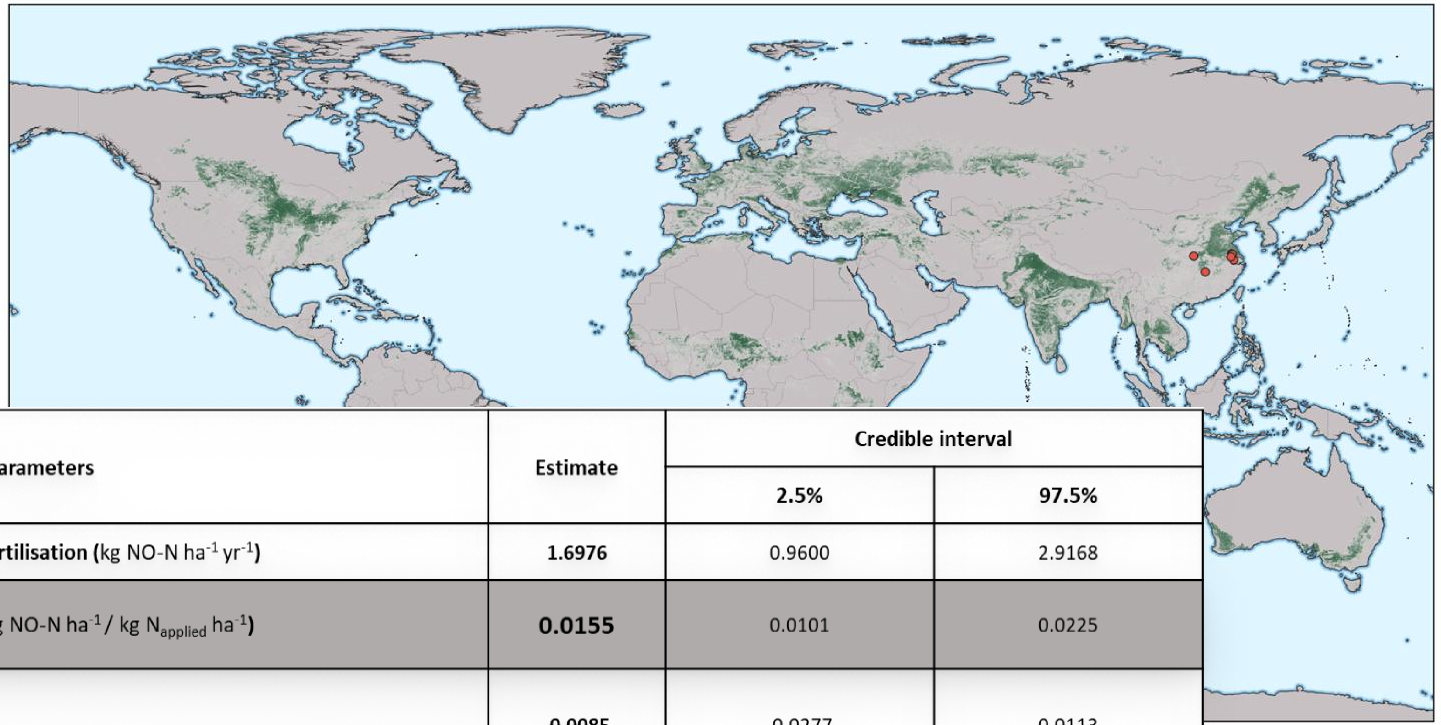
(95% credible intervals given in brackets)

Crop group / Climate zone	Wheat	Maize	Grassland	Vegetable	Other crops
Temperate	**0.29** (0.14, 0.46)	**0.37** (0.07, 0.68)	**0.21** (-0.16, 0.72)	**0.19** (-0.1, 0.51)	**0.41** (0.01, 0.91)
Continental	**0.38** (0.04, 0.72)	**0.46** (-0.03, 0.94)	**0.3** (-0.26, 0.98)	**0.28** (-0.2, 0.77)	**0.5** (-0.09, 1.17)
Desert (Irrigated)	**0.15** (-0.41, 0.92)	**0.23** (-0.48, 1.14)	**0.07** (-0.71, 1.18)	**0.05** (-0.65, 0.97)	**0.27** (-0.54, 1.37)
Tropical rainforest	**1.22** (0.69, 1.89)	**1.3** (0.62, 2.11)	**1.14** (0.39, 2.15)	**1.12** (0.45, 1.94)	**1.34** (0.56, 2.34)
Tropical savanna	**0.23** (-0.1, 0.54)	**0.31** (-0.17, 0.76)	**0.15** (-0.4, 0.8)	**0.13** (-0.34, 0.59)	**0.35** (-0.23, 0.99)
Tropical wet	**0.32** (-0.02, 0.66)	**0.4** (-0.09, 0.88)	**0.24** (-0.32, 0.92)	**0.22** (-0.26, 0.71)	**0.44** (-0.15, 1.11)

Emission factor for Organic N input : (% of NO-N emitted / kg $N_{applied}$ ha^{-1})

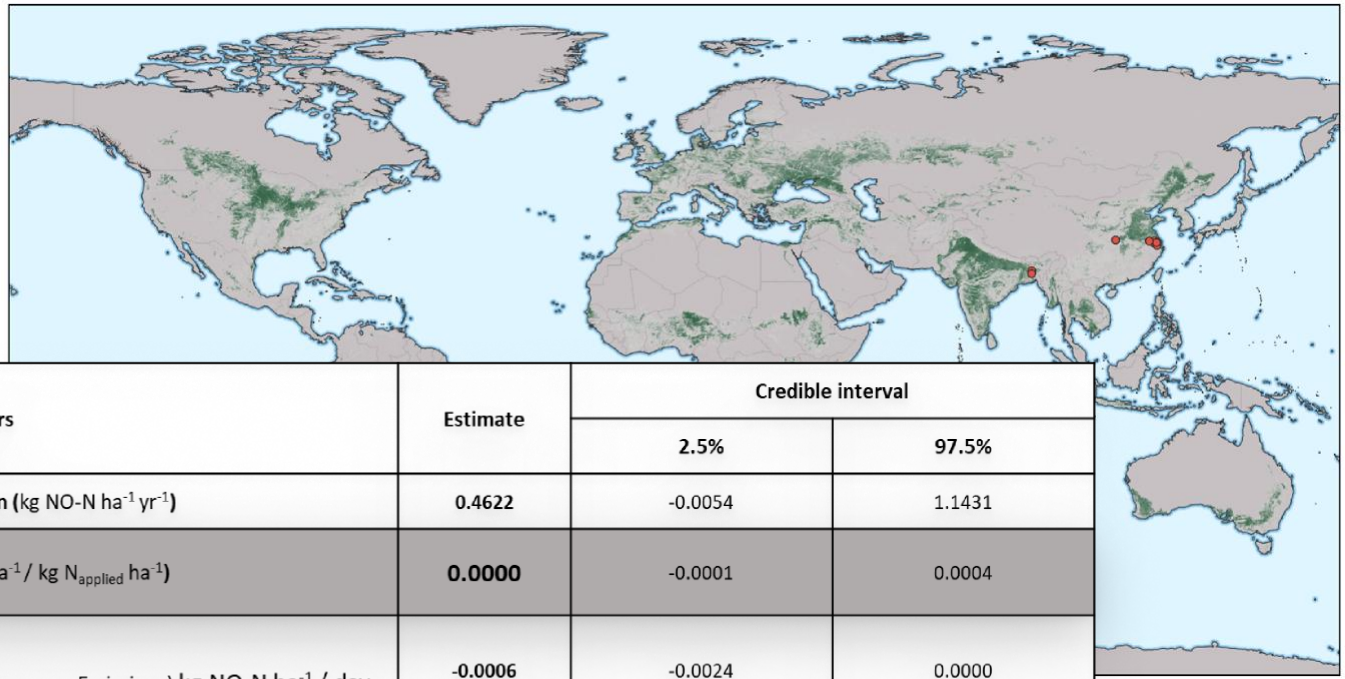
Applies to all crops & climate zones: 0.01 (-0.03, 0.05)

Model results: Tea



Parameters	Estimate	Credible interval	
		2.5%	97.5%
Emission at zero fertilisation (kg NO-N ha^{-1} yr^{-1})	**1.6976**	0.9600	2.9168
Emission factor (kg NO-N ha^{-1} / kg $N_{applied}$ ha^{-1})	**0.0155**	0.0101	0.0225
Length of experiment (Longer experiments = higher cum. Emissions) kg NO-N ha^{-1} / day	**-0.0085**	-0.0277	0.0113

Model results: Paddy Rice



Parameters	Estimate	Credible interval	
		2.5%	97.5%
Emission at zero fertilisation (kg NO-N ha^{-1} yr^{-1})	0.4622	-0.0054	1.1431
Emission factor (kg NO-N ha^{-1} / kg $N_{applied}$ ha^{-1})	**0.0000**	-0.0001	0.0004
Length of experiment (Longer experiments = higher cum. Emissions) kg NO-N ha^{-1} / day	-0.0006	-0.0024	0.0000

Key results

- The new emission factor for NO emissions,

  Synthetic N input: 0.42% (0.35 – 0.49%)

  Organic N input: 0.03% (-0.03 – 0.09%)

  ….is significantly lower than the current EF: 1.33% (0.15-3.17%)

- NO emissions significantly lower with organic fertilisers than synthetic fertilisers.
- Globally, non-uniform spread of studies. Need for more number of wide-spread studies.
- Focus on long-term measurements is needed in the future.

Key results: Impact on inventory

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ABSTRACT

Nitric Oxide (NO), an intermediate prod
health effects, including contribution to
Accurate quantification of NO emissions i
in national greenhouse gas and air pollut
an updated assessment based on recent fi

Country	Inorganic N-fertilizers (includes also urea application) kt N	NO2 kt N	New EF NO-N	New EF NO2	New NO2 emissions
France	1732.95	69.32	0.0042	0.0138	23.91
Poland	1039.8	41.45	0.0042	0.0138	14.35
Germany	1037.17	40.89	0.0042	0.0138	14.31
Spain	773.01	30.92	0.0042	0.0138	10.67
Italy	493.66	19.75	0.0042	0.0138	6.81
Romania	463.66	18.55	0.0042	0.0138	6.4
Bulgaria	340.8	13.63	0.0042	0.0138	4.7
Czechia	283.7	11.35	0.0042	0.0138	3.92
Ireland	280.57	10.8	0.0042	0.0138	3.87
Hungary	265.53	10.62	0.0042	0.0138	3.66
Netherlands	215.36	8.49	0.0042	0.0138	2.97
Denmark	197.35	7.89	0.0042	0.0138	2.72
Sweden	180	7.36	0.0042	0.0138	2.48
Greece	170.01	6.8	0.0042	0.0138	2.35
Finland	140.92	5.64	0.0042	0.0138	1.94
Belgium	128.56	5.14	0.0042	0.0138	1.77
Lithuania	118.55	4.74	0.0042	0.0138	1.64
Slovakia	107.61	4.3	0.0042	0.0138	1.48
[illegible]	[illegible]	3.75	0.0042	0.0138	1.3
[illegible]	[illegible]	3.6	0.0042	0.0138	1.23
[illegible]	[illegible]	3.47	0.0042	0.0138	1.2
[illegible]	[illegible]	3.21	0.0042	0.0138	1.11
[illegible]	[illegible]	1.54	0.0042	0.0138	0.53
[illegible]	[illegible]	1	0.0042	0.0138	0.34
[illegible]	[illegible]	0.36	0.0042	0.0138	0.13
[illegible]	[illegible]	0.16	0.0042	0.0138	0.06
[illegible]	[illegible]	0.08	0.0042	0.0138	0.03

Average difference between Old & New estimates

=

65%

Implications for EMEP/EEA Guidebook

Proposed updates to Chapter 3D:

1. Reduce default EF from 1.33% to 0.42% for synthetic N
2. Add separate organic N EF: 0.03%
3. Add crop-specific EFs for tea plantations and paddy rice systems

Expected impact:

- Substantial decrease in reported NO emissions from agricultural soils for countries using mostly synthetic fertiliser
- Improved precision supports EU National Emission Ceilings Directive compliance