Latest proxies for spatial distribution for the agricultural sector – Norway case

Susana Lopez-Aparicio, Henrik Grythe and Miha Markelj

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Motivation

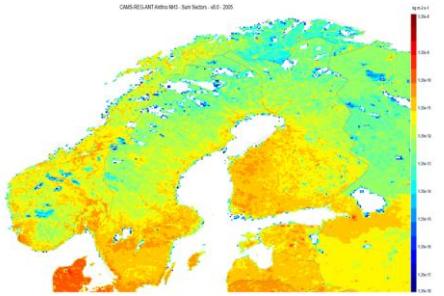
Why developing new proxies?

FAIRMODE activity - 3 inventories were benchmarked (NordSmoke, CAMS & EMEP) resulting in large inconsistencies

- NordSmoke emission inventory (NILU); **GNFR – K:** Each NFR category: number / type of livestock per municipality (SSB) and land use category (pastures; CORINE); **GNFR – L**: land use category (farmlands crops; CORINE)

- CAMS - Proxies
  - **GNFR – K**: Gridded livestock (FAO, 2010) per animal and type converted to 0.05 x 0.1∘ resolution.
  - **GNFR – L**: CAPRI model distribution and CORINE land cover 2012 arable land

- EMEP – Proxies: [NO IIR 2025]
  - *When figures for the activity used to calculate emissions are available directly at geographical level, these figures are used. Examples are fuel combustion in manufacturing industries and emissions from animals.*



Norway- Totals [GNFR K and L]
CAMS **=** NordSmoke **=** EMEP

Oslo FUA [Oslo + Akershus]
CAMS **x 3.5** = NordSmoke **x 7** = EMEP

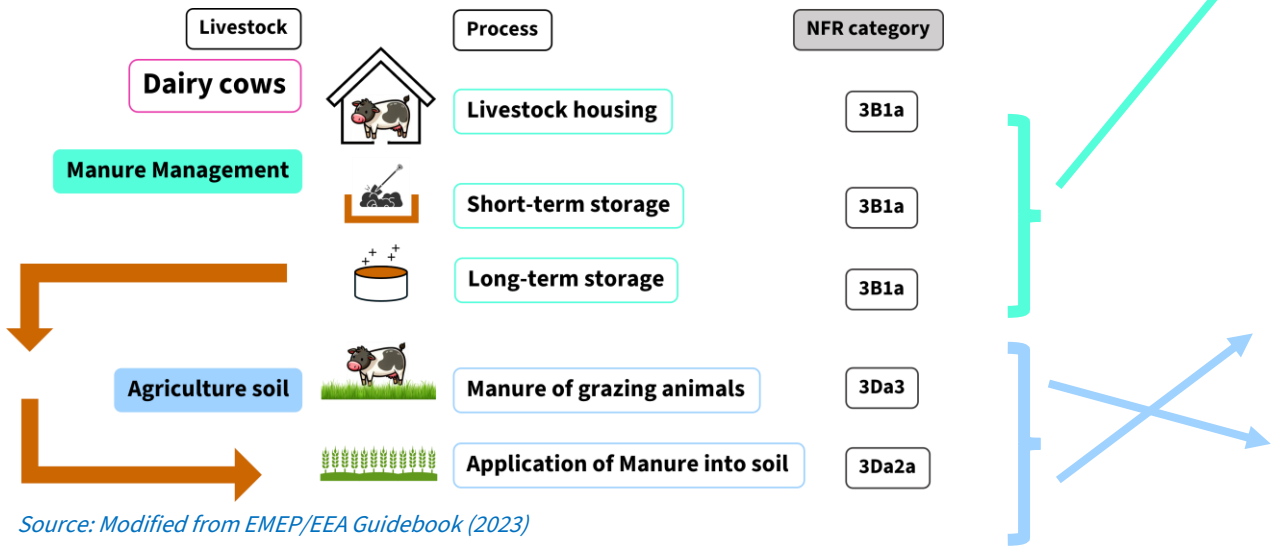
Similar differences for other FUA's…

Inconsistent spatial distribution

Motivation

Develop a high-resolution data geoprocessing model using local data and representing the processes behind agriculture emissions

We use national official emissions and focus on the spatial distribution of that at the NFR level



Source: Modified from EMEP/EEA Guidebook (2023)

NO: 01.02.2021: 2019	NFR sectors to be reported		Main Pollutants (from 1990)			
			NOx (as NO_2)	NMVOC	SOx (as SO_2)	NH_3
NFR Aggregation for Gridding and LPS (GNFR)	NFR Code	Long name	kt	kt	kt	kt
K_AgriLivestock	3B1a	Manure management - Dairy cattle	0.01	3.51	NA	4.00
K_AgriLivestock	3B1b	Manure management - Non-dairy cattle	0.04	3.58	NA	4.22
K_AgriLivestock	3B2	Manure management - Sheep	0.02	0.30	NA	0.89
K_AgriLivestock	3B3	Manure management - Swine	0.00	0.29	NA	1.43
K_AgriLivestock	3B4d	Manure management - Goats	0.00	0.04	NA	0.11
K_AgriLivestock	3B4e	Manure management - Horses	0.02	0.51	NA	0.52
K_AgriLivestock	3B4gi	Manure mangement - Laying hens	0.02	0.36	NA	0.34
K_AgriLivestock	3B4gii	Manure mangement - Broilers	0.01	0.56	NA	0.30
K_AgriLivestock	3B4giv	Manure management - Other poultry	0.00	0.06	NA	0.09
K_AgriLivestock	3B4h	Manure management - Other animals (please specify in IIR)	0.00	0.03	NA	0.08
L_AgriOther	3Da1	Inorganic N-fertilizers (includes also urea application)	4.27	NA	NA	1.14
L_AgriOther	3Da2a	Animal manure applied to soils	2.24	2.45	NA	11.35
L_AgriOther	3Da2b	Sewage sludge applied to soils	0.06	NA	NA	0.25
L_AgriOther	3Da2c	Other organic fertilisers applied to soils (including compost)	0.02	NA	NA	0.06
L_AgriOther	3Da3	Urine and dung deposited by grazing animals	0.95	0.09	NA	1.77
L_AgriOther	3F	Field burning of agricultural residues	0.10	0.02	0.02	0.10
L_AgriOther	3I	Agriculture other (please specify in the IIR)	NA	NA	NA	0.38

Source: Annex I – Norwegian EPA

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GRAIN – model building blocks

Farm-level NH3-emissions from agriculture in Norway

HOUSING and STORAGE

LIVESTOCK

- Livestock number & type
- *[Building point _ Production subsidies, NO Agriculture Agency]*

BARN & STORAGE

- Geolocation of barns
- *[Building point _ Property Registry, NO Mapping Authority]*

FARMS

- **Farm geolocation**
- *[Building point _ NO Agriculture Agency]*

GRAZING

PASTURE & FREE RANGE

- Areas for grazing
- *[Polygons _ Land Accounts map (AR50) and Free Range land areas, NIBIO]*

FERTILIZATION

CROPS and GREENHOUSES

- Crops where fertilizer (inorganic, manure) are applied
- *[Polygons _ Land Accounts map (AR50), NIBIO AND Property Registry]*

AGRICULTURE CENSUS

- Manure storage system, spreading equipment and time
- *[Municipality _ Statistics Norway]*

FROM STORAGE TO FIELDS

KEY

DATASET

- Short description
- *[Resolution _ Data source]*

Input data (Points and Areas)

HOUSING and STORAGE

FARMS

- **Farm geolocation**
- *[Building point _ NO Agriculture Agency]*

BARN & STORAGE

- Geolocation of barns
- *[Building point _ Property Registry, NO Mapping Authority]*

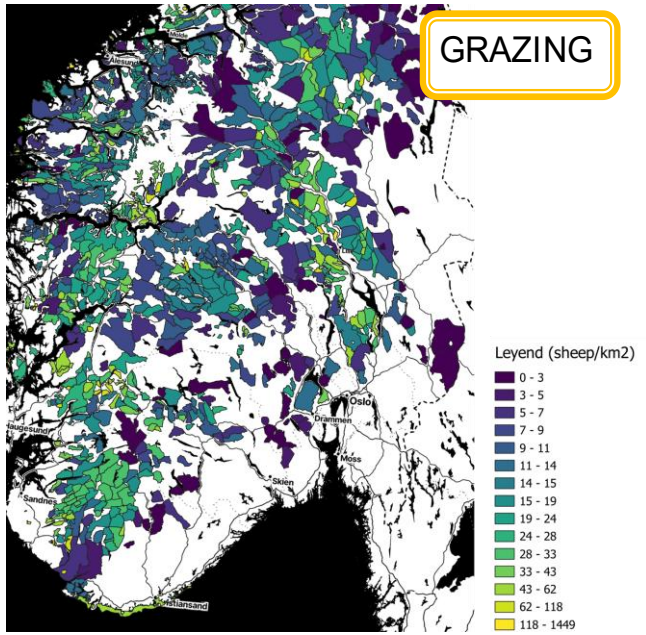
LIVESTOCK

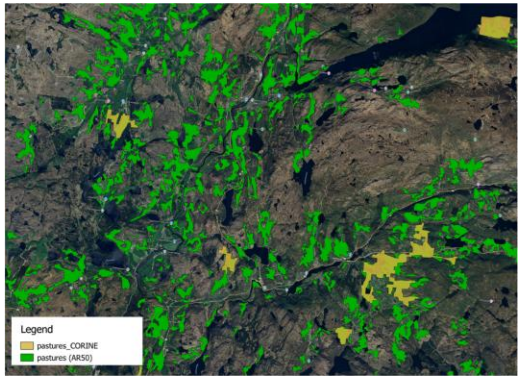
- Livestock number & type
- *[Building point _ Production subsidies, NO Agriculture Agency]*

Data per Farms entity:

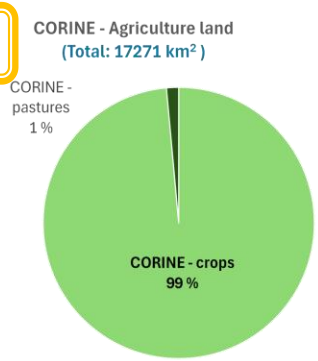
- Subsidy (NOK)
- # animals per livestock type
- Animals on pasture
- Areas for vegetable / potato production
- Ecological production
- Production (type and kg)
- …

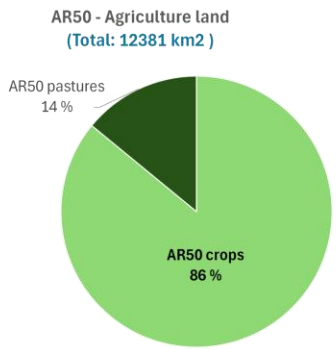
GRAZING





FERTILIZATION





GRAZING

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Geoprocessing
Matching Farm-Level Activity Data

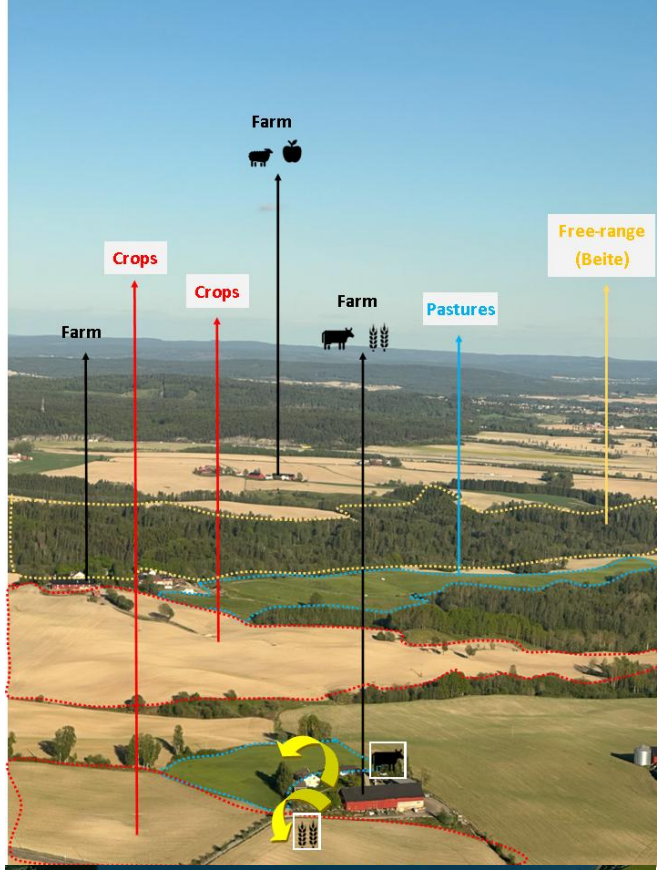
1) Artificial segmentation of larger fields to improve the spatial resolution (AR50)

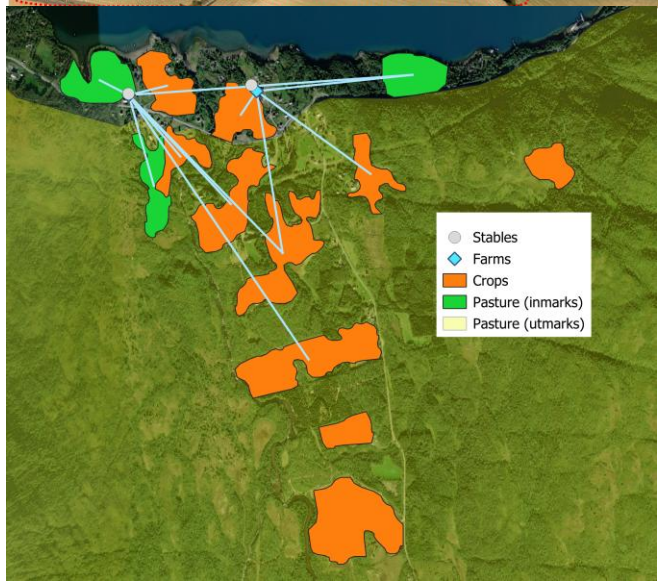
2) Livestock allocation to barns based on building floor area, filling to capacity (starting with largest building)

3) Matching agricultural land to farms based on reported agricultural area for vegetable/potato production (subsidies dataset), combined AR50 (land use), based on proximity

4) Animal grazing in pastures and outfields based on animals grazing (subsidy dataset), AR50 pasture (land use), beite area, capacity (pasture) and proximity (outfield)

5) Manure units (*mu*), *represent NH3 emission potential*, i) each animal type is converted into *mu* based on national factors, ii) allocate *mu* to processes
   - Housing and storage: at the barns (# and type of animals).
   - Grazing, We used the time share (housing and grazing) (IIR 2025)
   - Manure application into agriculture soil (mu from barns - 1 *mu* per 4 dekar).





Geospatial distribution of emissions

Distribution keys for NFR categories

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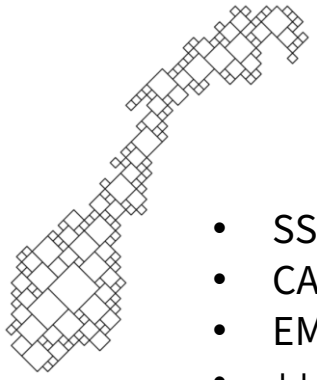
Source: Annex I – Norwegian EPA



OUTPUT

- SSB250mGrid
- CAMS
- EMEP
- +++

Gridded emissions

Downscaled emissions

Point

Polygon

Manure units in barns
(type of livestock)

Crop areas
(farms with non-eco production and no manure)

Crop areas
(farms with manure)

Crop areas
(farms with eco production and no manure)

Crops

Manure units on pastures
(inmarks - utmarksbeite)

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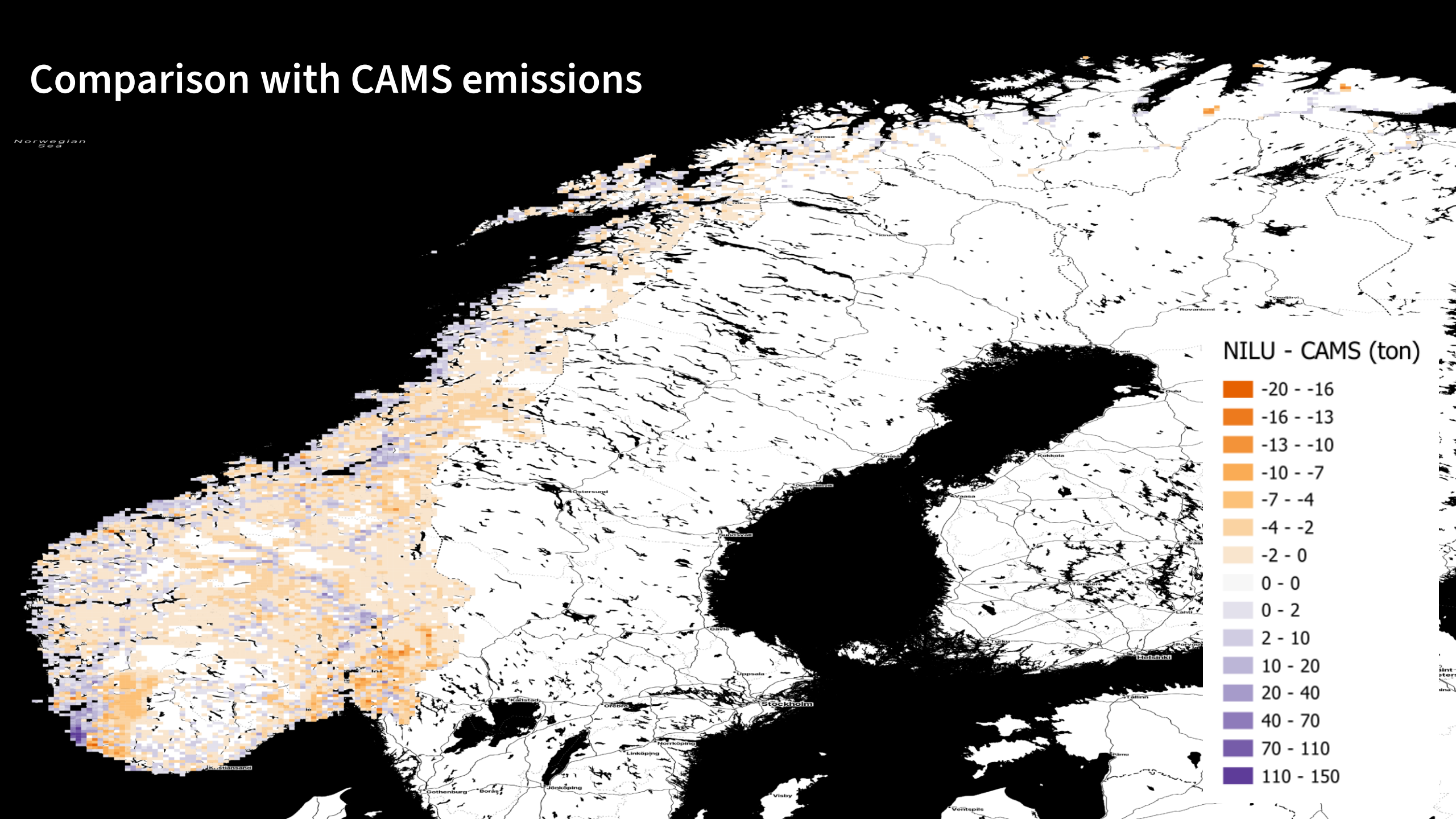
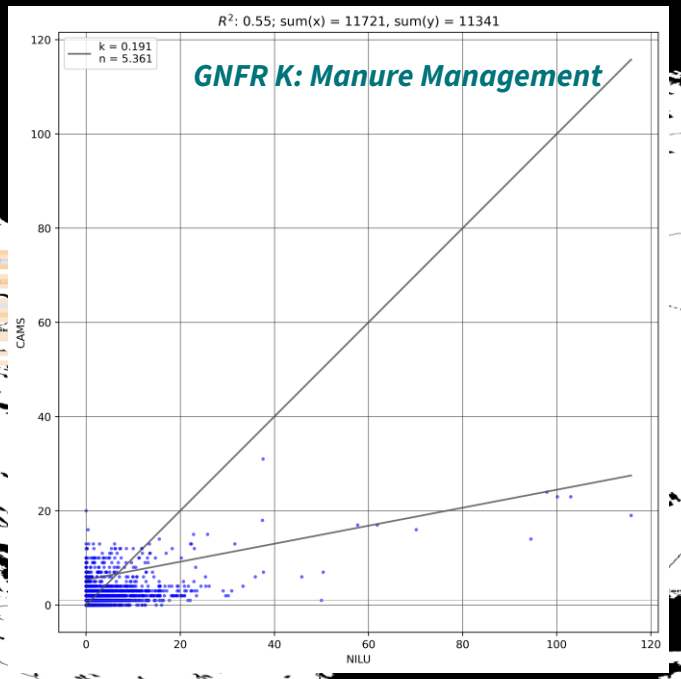
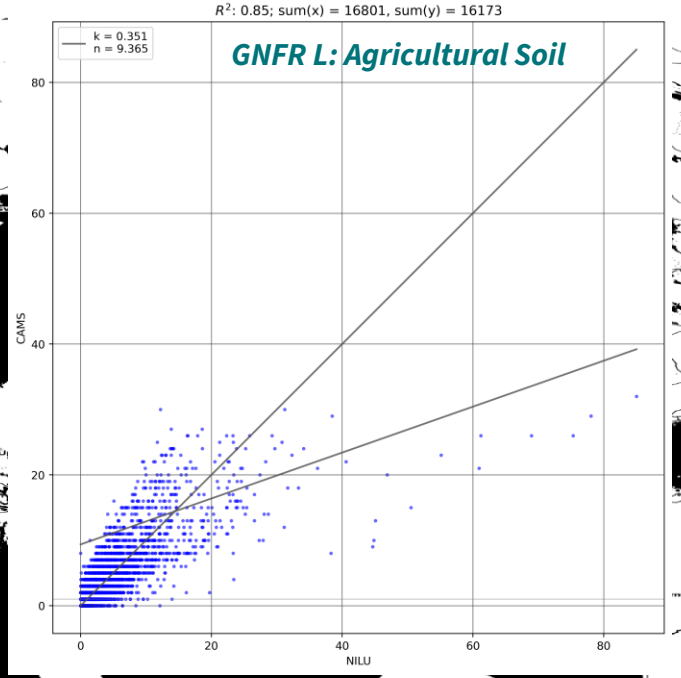
Comparison with CAMS emissions



Comparison with CAMS emissions



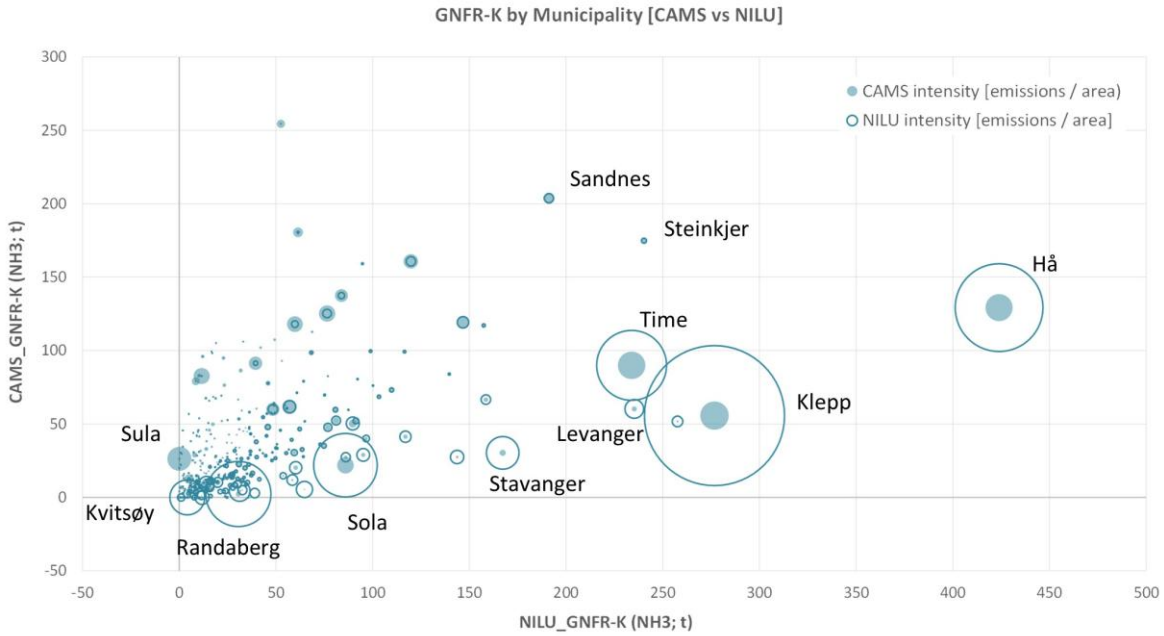


NILU - CAMS (ton)

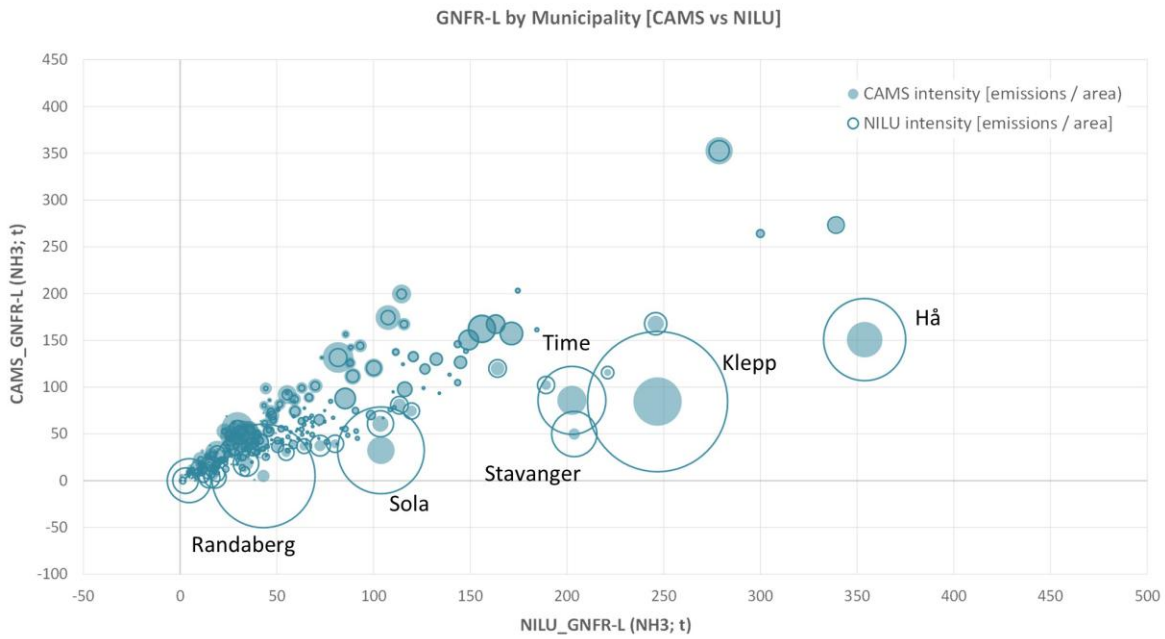
- -20 - -16
- -16 - -13
- -13 - -10
- -10 - -7
- -7 - -4
- -4 - -2
- -2 - 0
- 0 - 0
- 0 - 2
- 2 - 10
- 10 - 20
- 20 - 40
- 40 - 70
- 70 - 110
- 110 - 150

Comparison with CAMS emissions per MUNICIPALITY

GNFR K: Manure Management

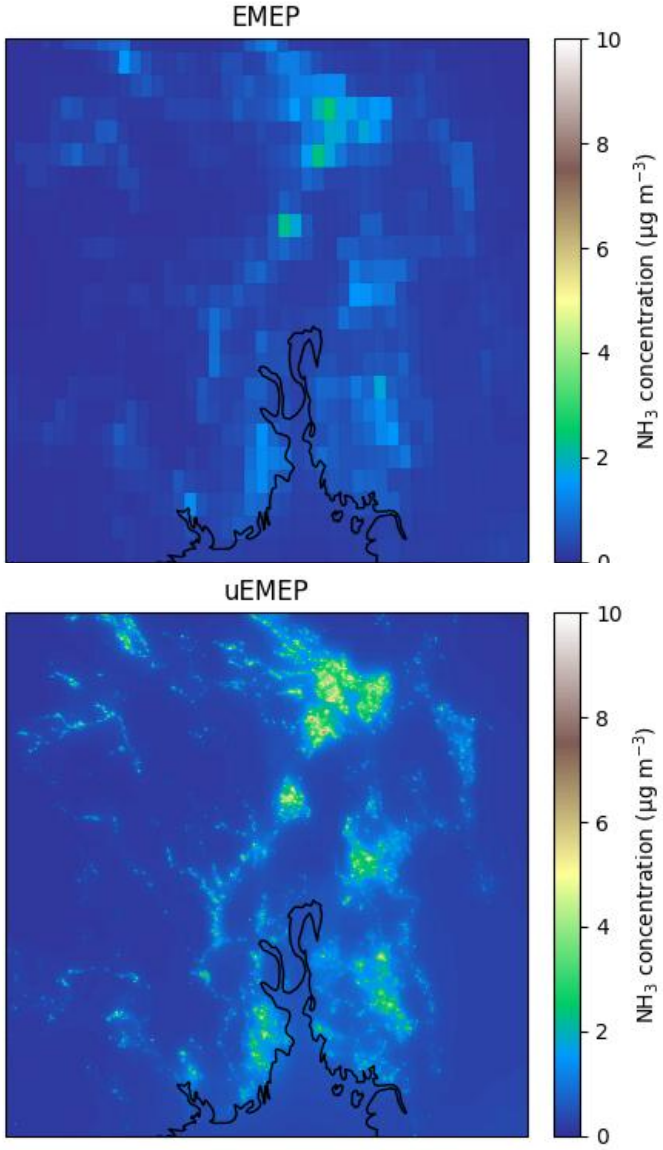


GNFR L: Agricultural Soil

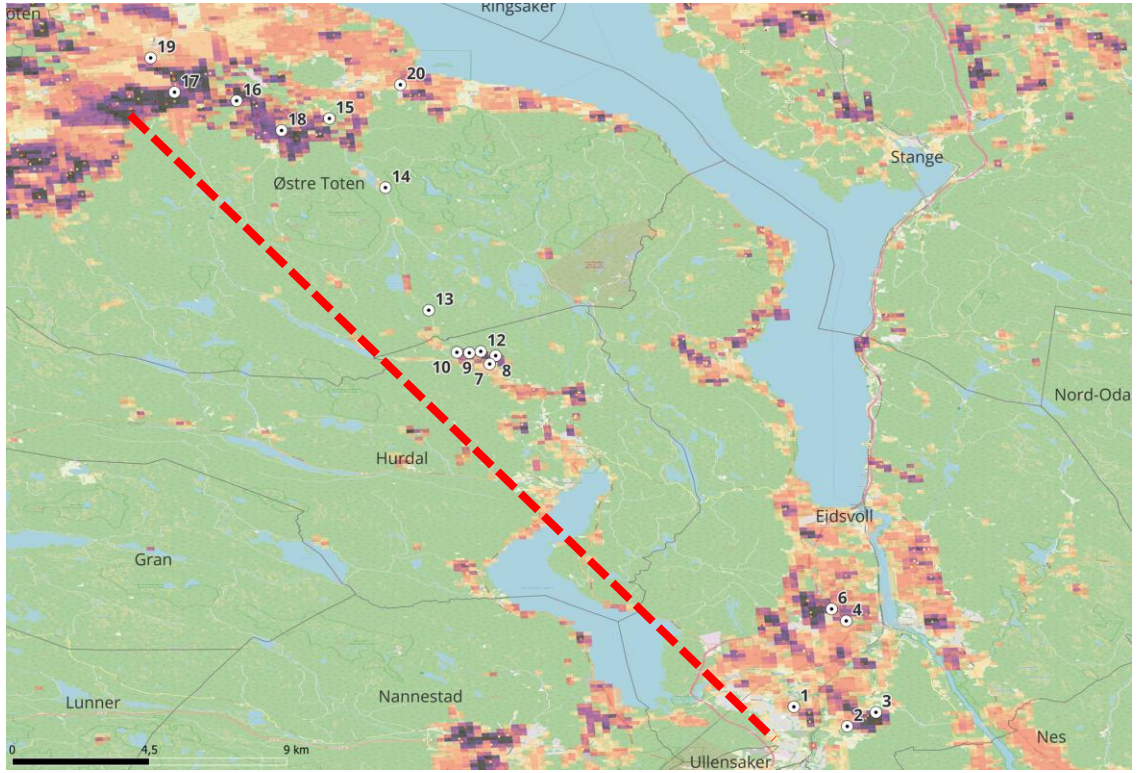


NH3 emissions: CAMS and NILU – emissions per land area

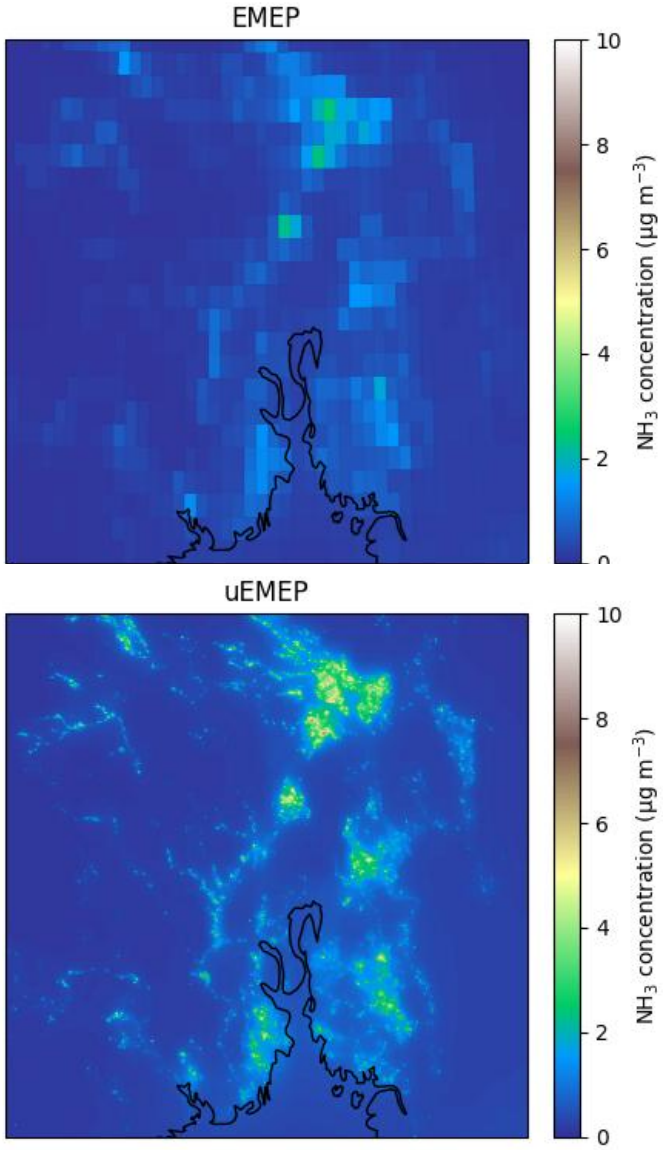
Validation - Ongoing work



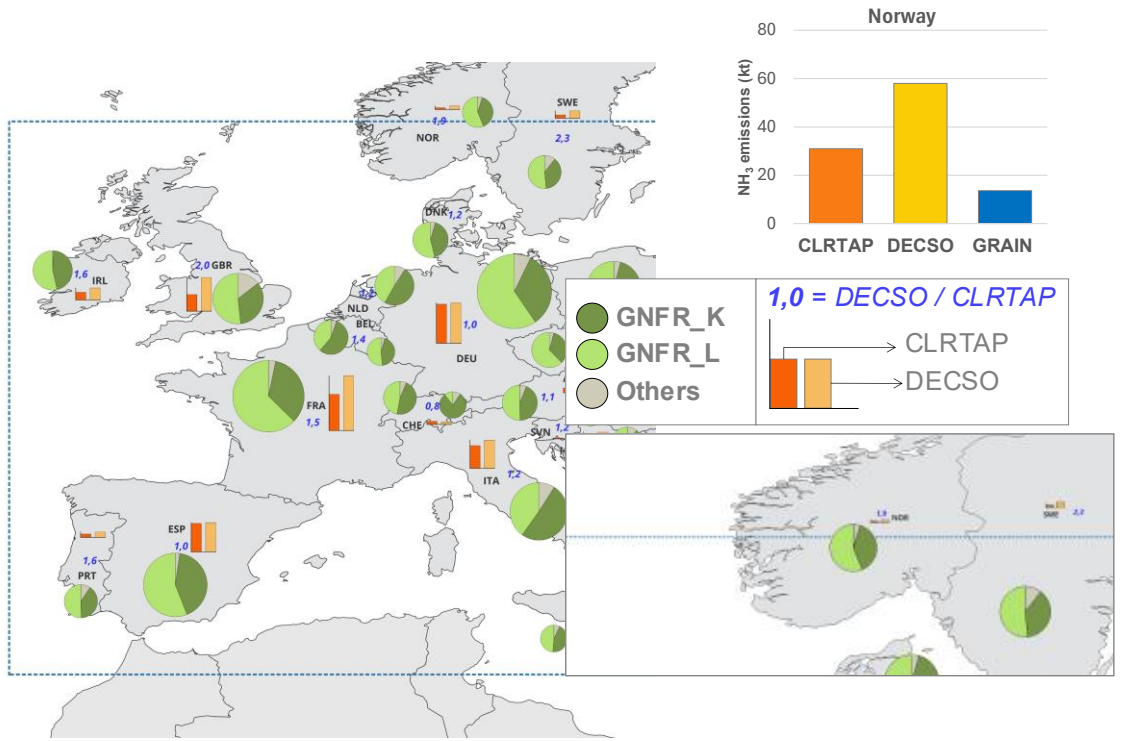
- Our results, still preliminary, need to be validated (e.g., measurements, modelling application, satellite observation)
  - Collaboration with met.no for their use in modelling applications;
  - We have carried out a measurement campaign (NH_3 passive samplers).

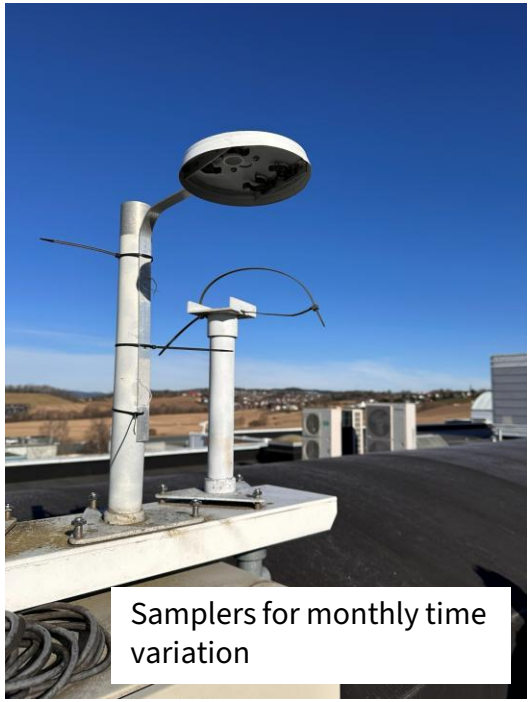


Validation - Ongoing work



- Our results, still preliminary, need to be validated (e.g., measurements, modelling application, satellite observation)
  - Collaboration with met.no
  - We have carried out a measurement campaign (NH_3 passive samplers)
  - Comparison with satellite – based emissions (GREENEO project), including time variations (DECSO monthly profiles ≈ constant)





Samplers for monthly time variation

Take home messages

The GRAIN model is designed to represent **the spatial and process-based characteristics of the agriculture sector:** i) *housing and storing* of manure; ii) *fertilization processes*, e.g., grazing, manure application, or other fertilizers).

Input data is essential; the **spatial resolution reflects that of the input data**. GNFR-K (manure management): *50.000 emission point sources;* while GNFR-L (agricultural soil): *400.000 polygons* (fields, meadows and pastures).

The GRAIN methodology/results have been discussed with the NO EPA, and the plans to implement it as part of the **gridded EMEP emissions** submitted to the CLRTAP.

Validation is still an ongoing process; modelling applications, measurements and satellite – based emissions, in addition to develop a method at European scale (GREENEO) based on the lesson learned.

Thank you for your attention

Susana Lopez-Aparicio, Henrik Grythe and Miha Markelj

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