THE NEED FOR RELIABLE GAS EMISSION MEASUREMENTS IN THE AGRICULTURAL SECTOR

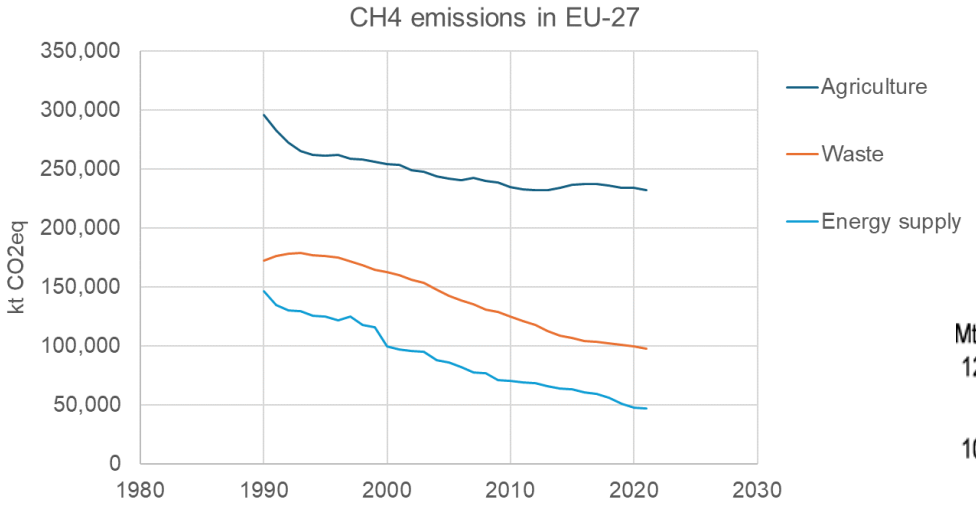
CONTENT OF PRESENTATION

Focus: Emissions from manure management – NH_3, GHG (VOC and H_2S)

- From global to local trends and regulatory incentives
- Source categories of importance
- Challenges in agricultural emission measurements
- Requirements for measurement methods and equipment (protocols)

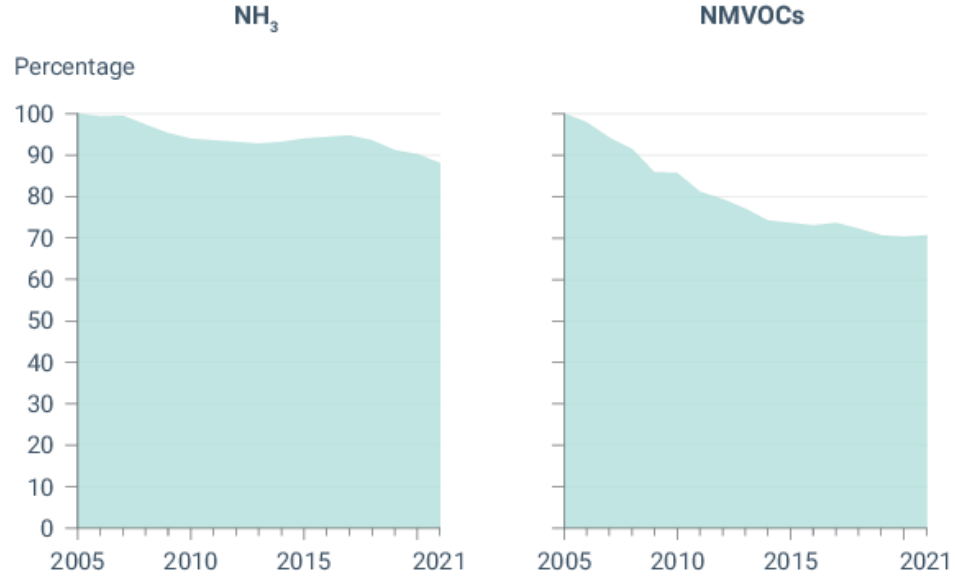
GLOBAL/EU TRENDS IN AGRO-EMISSIONS

- EU: Despite emission reduction targets, agricultural emissions are stagnating

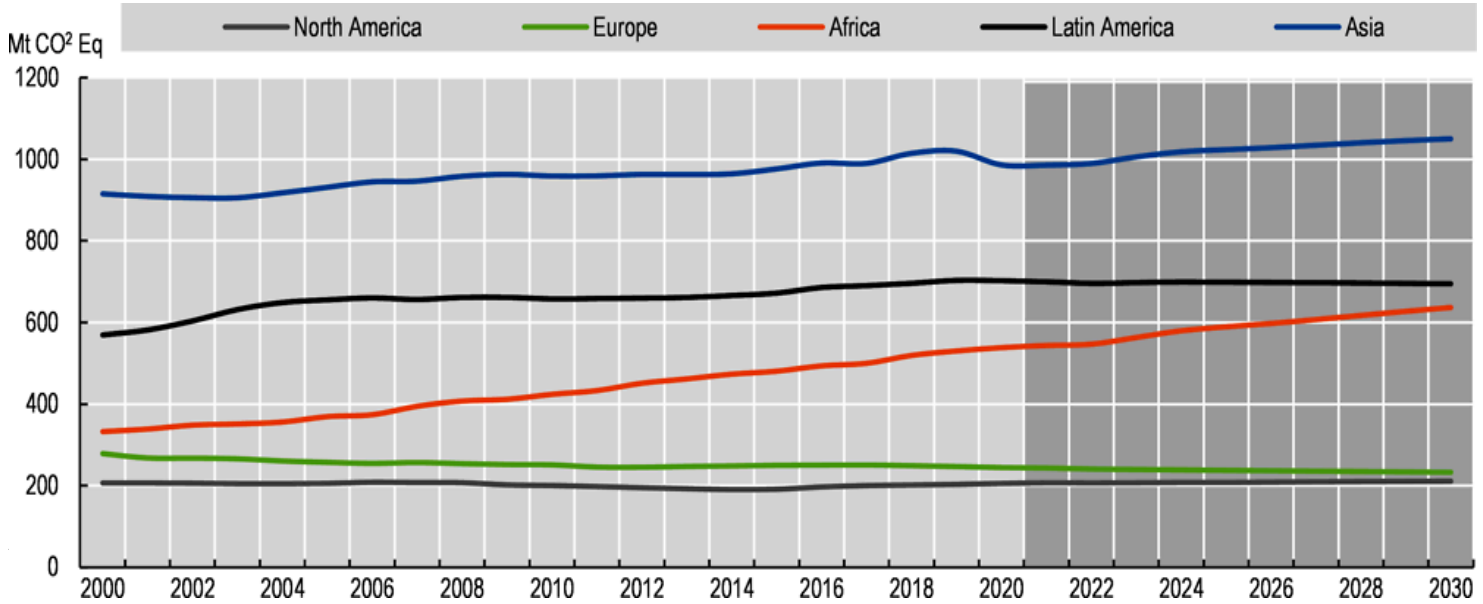


- Global demand for animal food is projected to increase (FAO)
- Global CH_4 emission from meat production will follow (FAO)

European emission trends (European Environment Agency)



CH_4 emissions from animal food products (FAO):

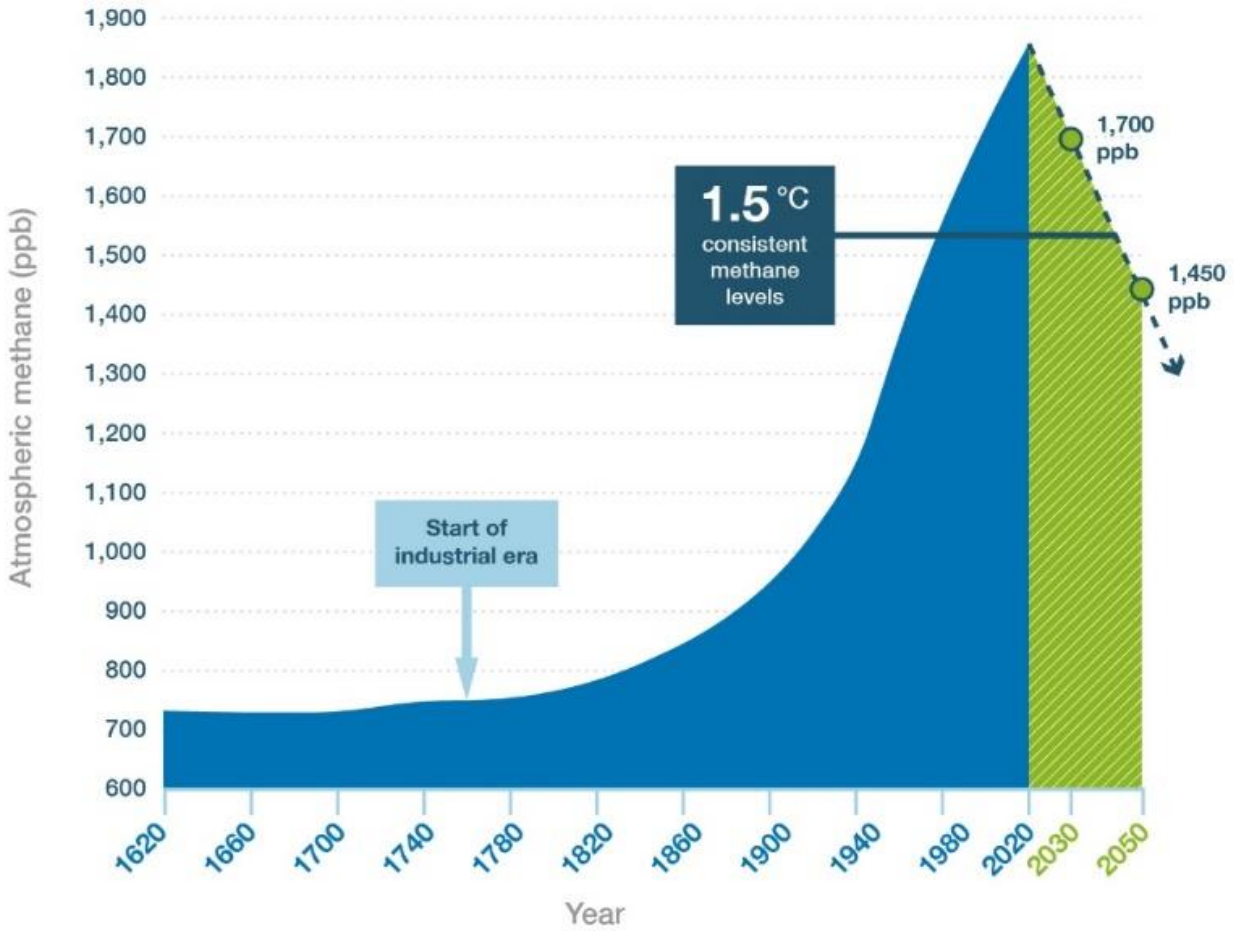


G
IN

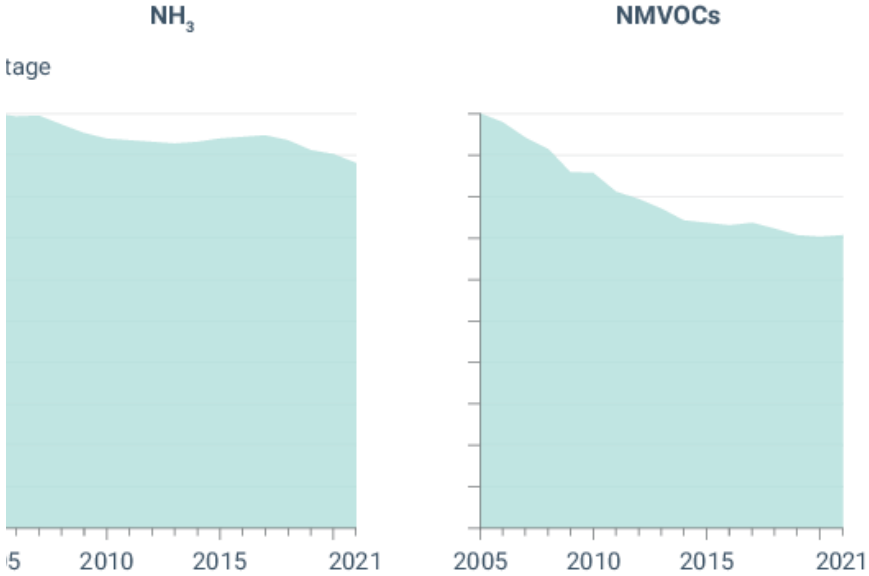
- E
  C

350
300
250
200
150
100
50
kt CO2eq

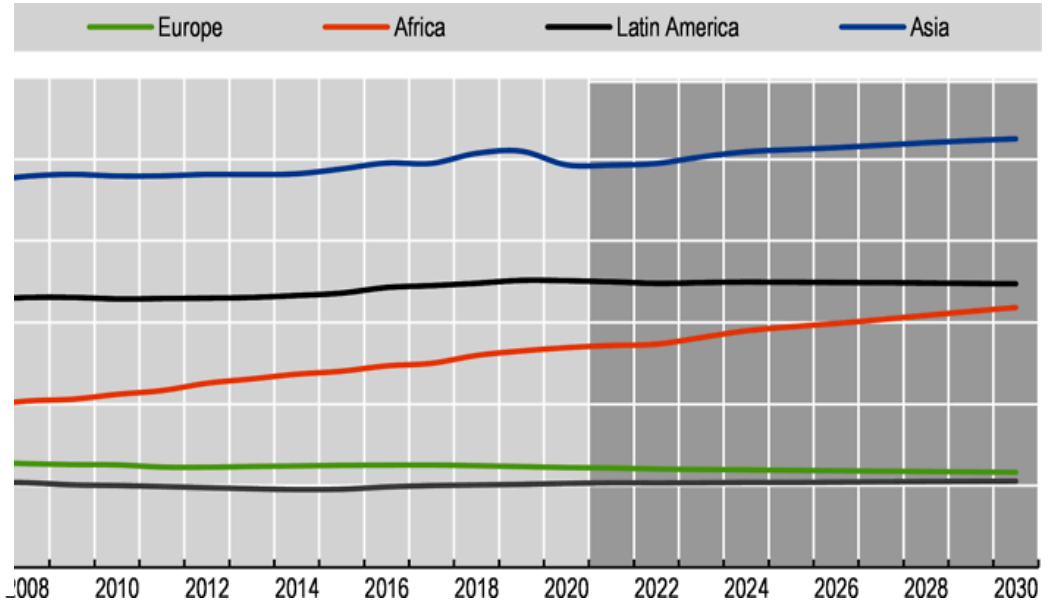
- C
  F
- C
  F



European emission trends (European Environment Agency)

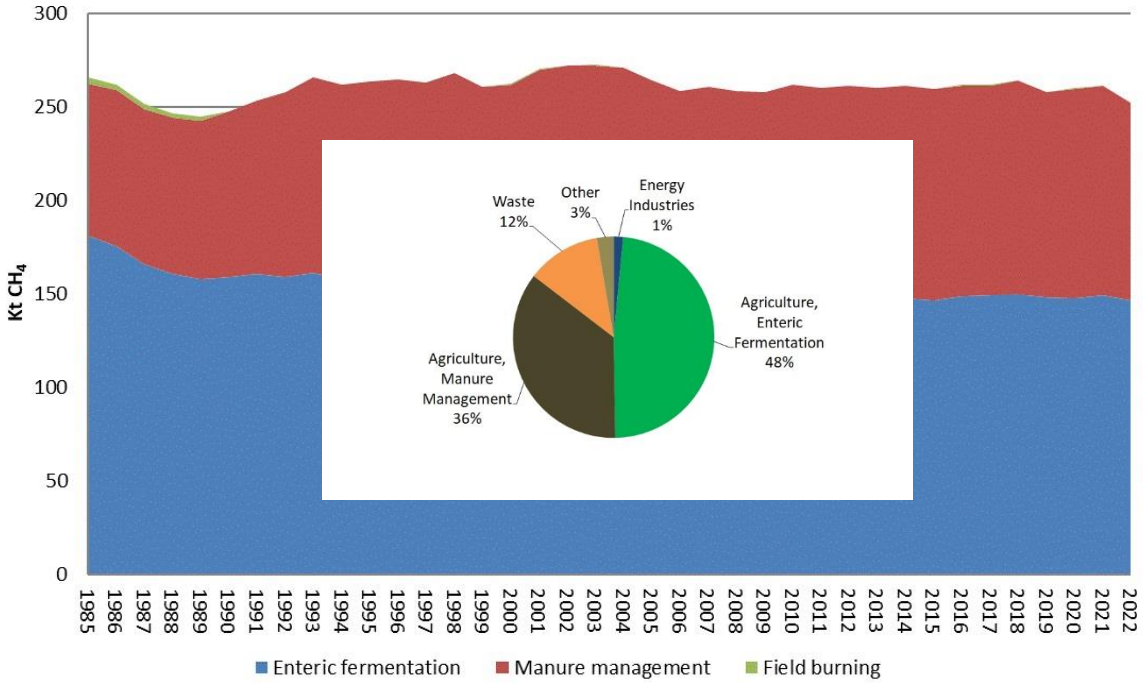


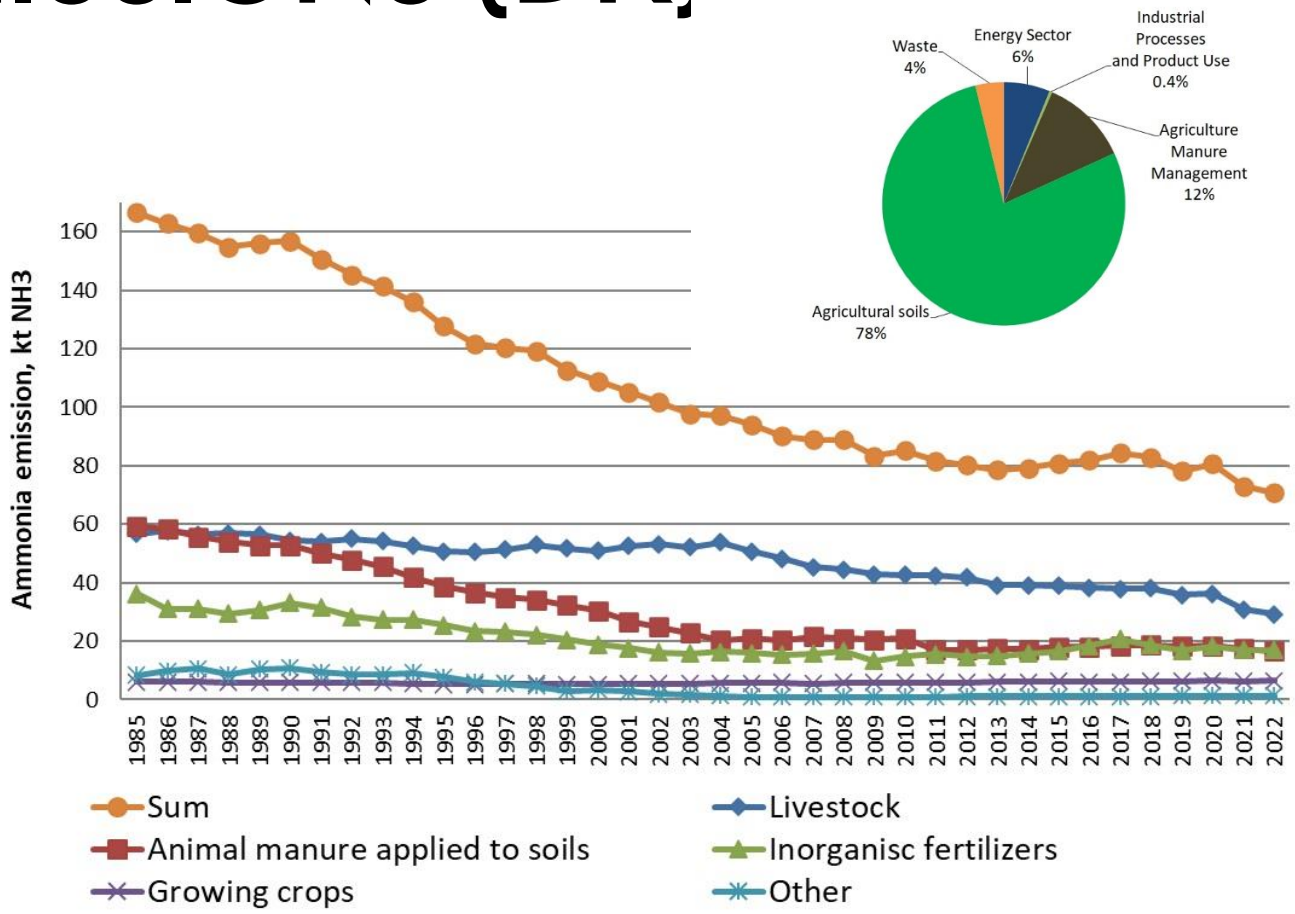
ons from animal food products (FAO):



LOCAL TRENDS IN EMISSIONS (DK)

- Data from DK national inventory

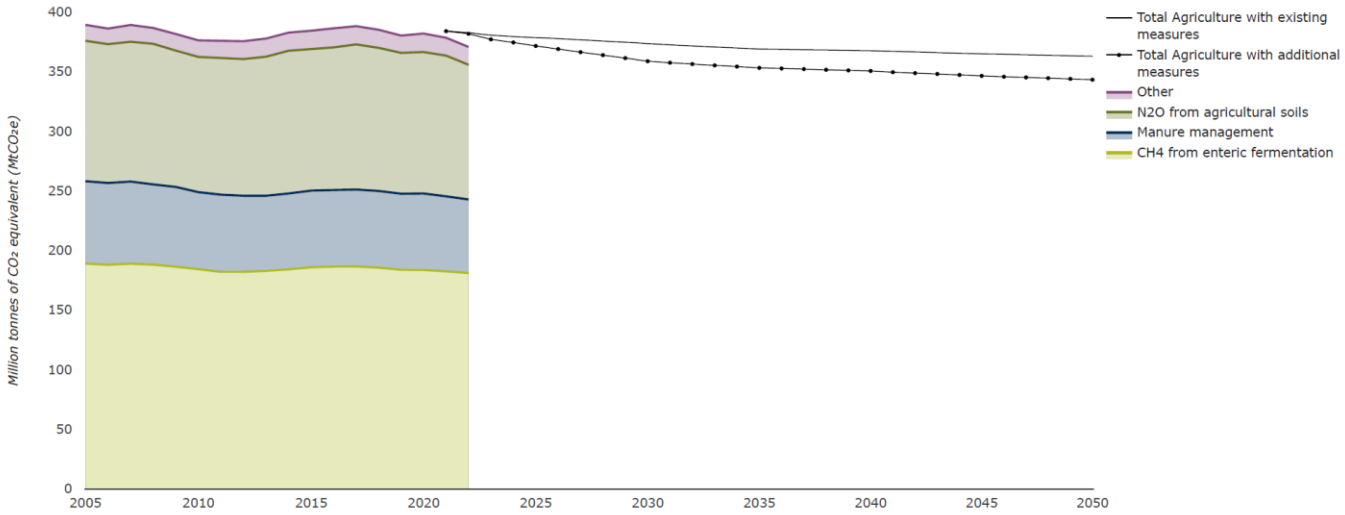


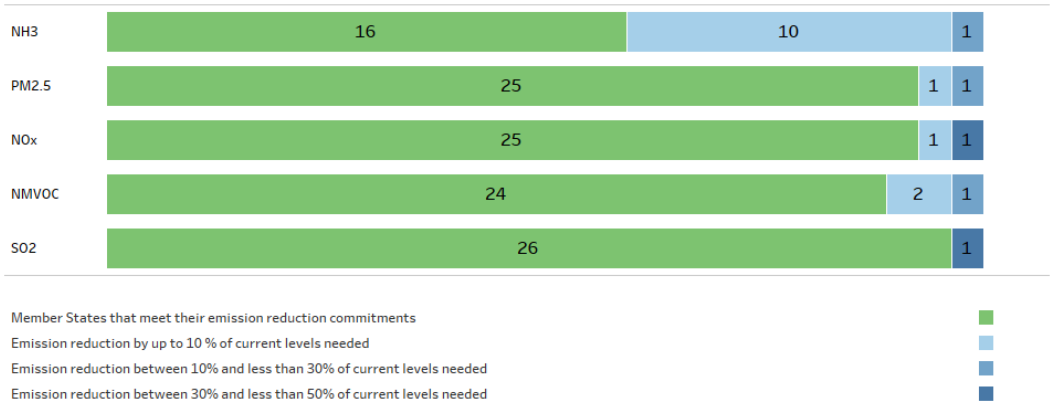


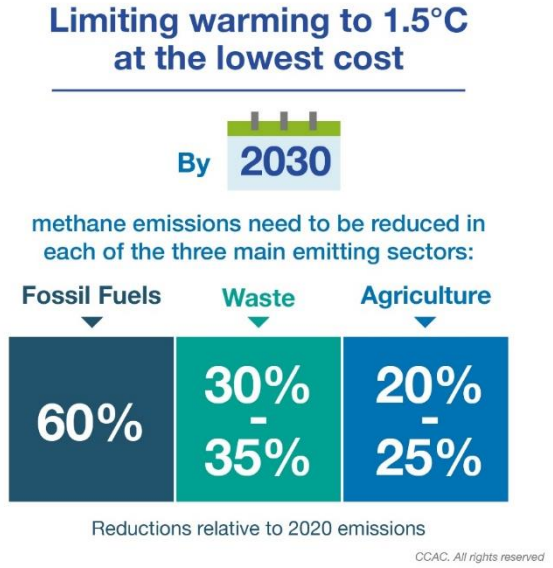
EMISSION REDUCTION NEEDS/TARGETS

- NH_3 and VOC emissions are included in Gothenburg protocol

Agricultural GHG are part of e.g. EU target of emission reduction of 55% in 2030

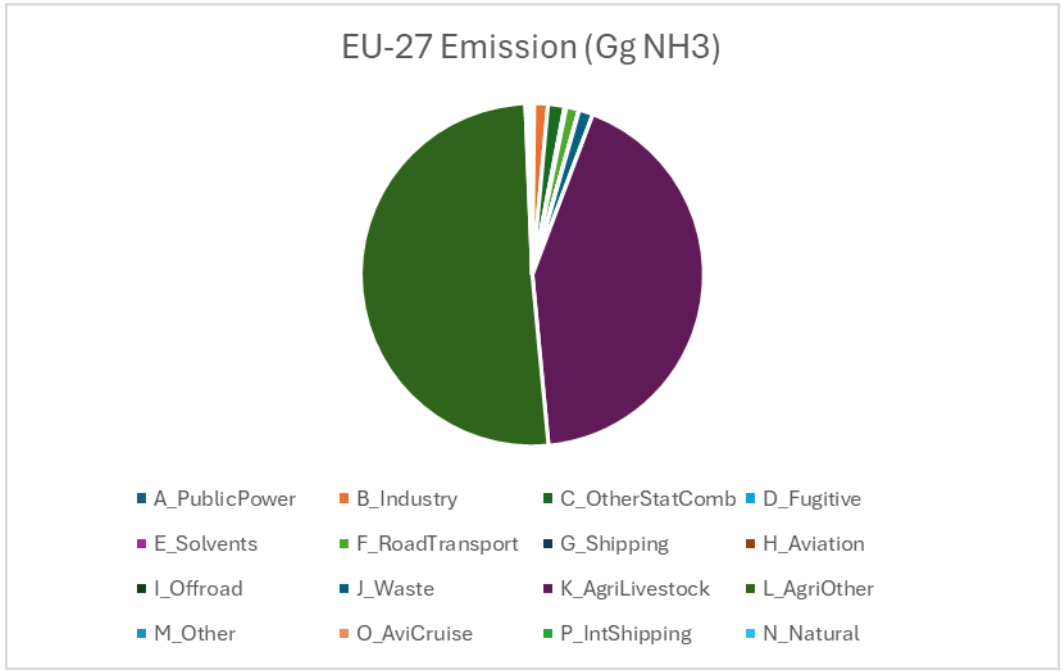


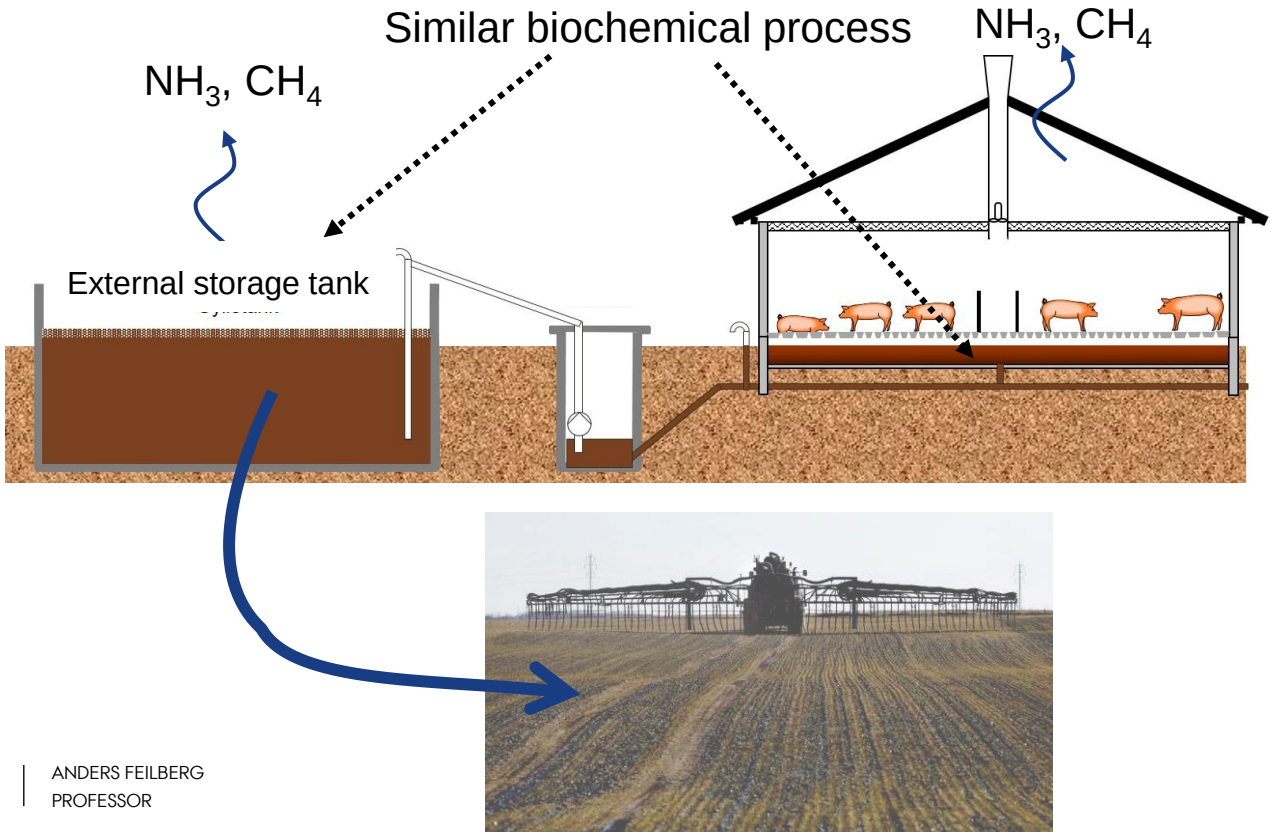




IMPORTANCE OF MANURE MANAGEMENT

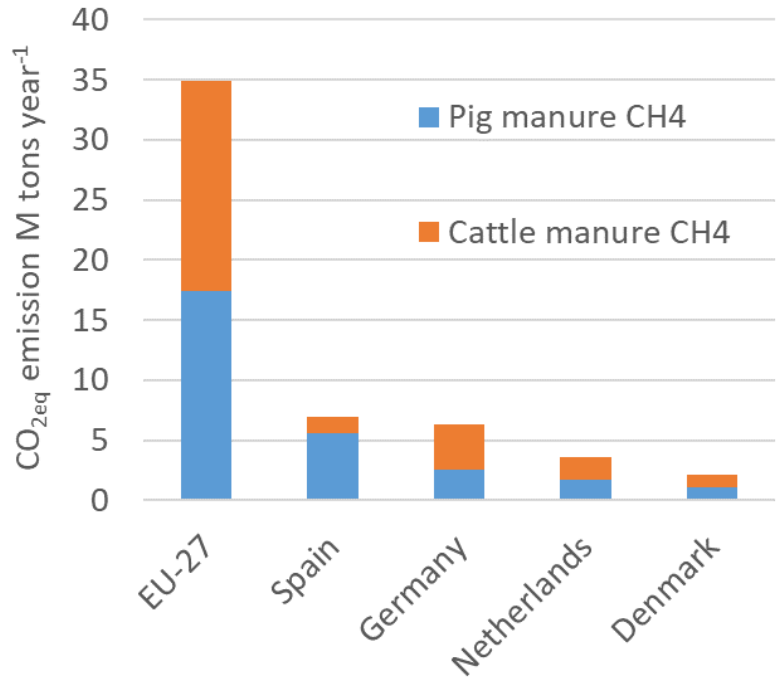
- Manure management is by far the primary source of NH_3 in EU
- Manure management is the second-largest source of CH_4 in EU (after enteric CH_4)





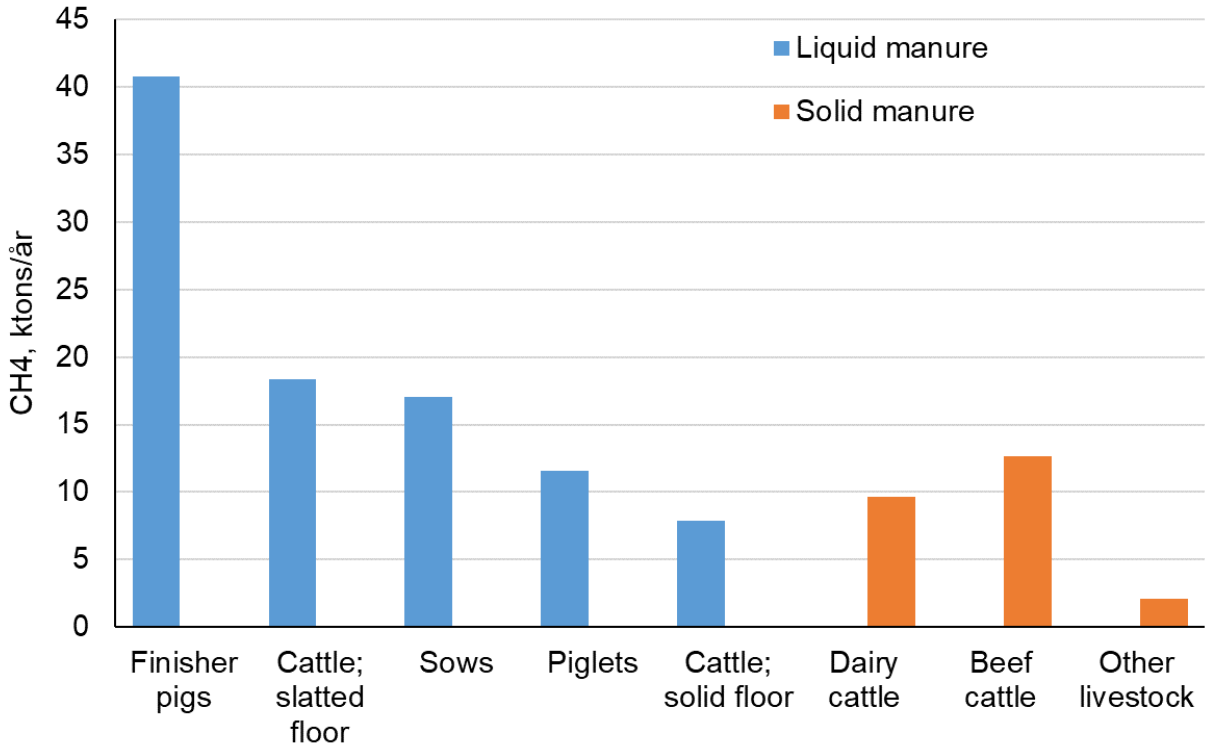
MANURE IN INTENSIVE LIVESTOCK SYSTEMS

- Storage in-house and outdoor as liquid manure (slurry): Cattle and pig production
- GHG contribution **dominated by CH_4** (90-95% of CO_{2eq})



SOLID MANURE CANNOT BE NEGLECTED

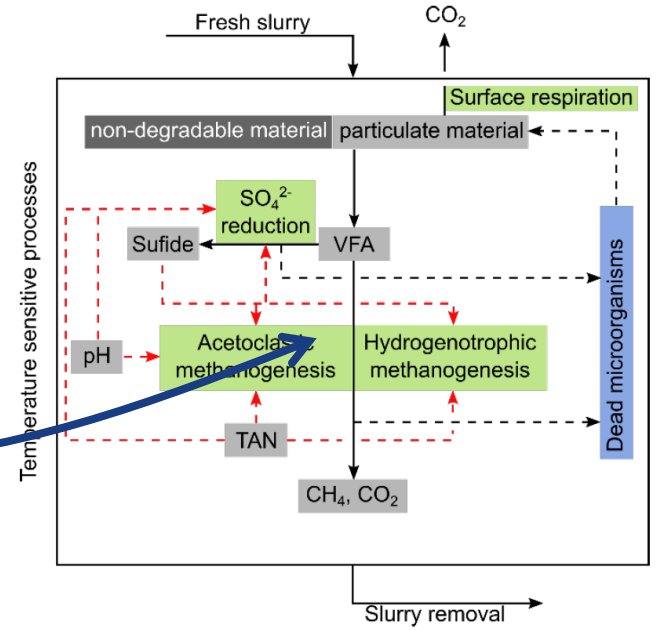
- Sources of CH_4 from manure management in Danish livestock production
- Data is extremely scarce, measurements are challenging
- In other countries, solid manure could have a bigger contribution



REGULATION OF EMISSIONS IN DK

- Primary target towards 2030 : GHG emissions! But more data is needed!
  - Less attention on NH_3 gas emission (N leaching and runoff is also high on the agenda)

- Current political negotiations concerning a GHG tax:
  - Suggestion: up to (!) 750 DKK (~100 Euro) per ton CO_{2eq}
  - Requires detailed quantification of emissions at a farm level.
    - Incl all sources, mitigation strategies, feed variability etc.
- Farm level emission accounting does not exist today (for GHG)
  - It cannot be based on measurements alone
    → models are needed, e.g. ABM



THE ROLE OF MEASUREMENTS...

- Reliable measurements are needed for:
  - Model development
  - Model validation and calibration
  - Development of technologies

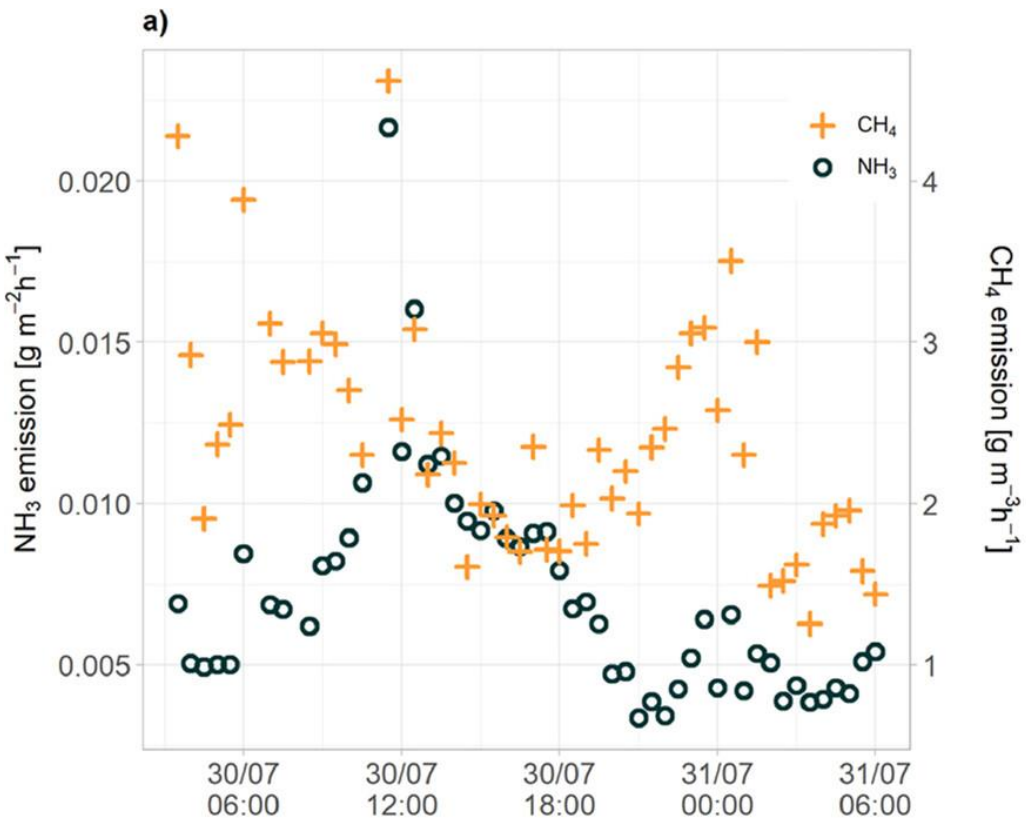
  - Reference emission data for all important categories for:
    - Maintaining national emission inventories
    - Documentation of mitigation technologies and strategies
    - Checking modelled farm emissions

MEASUREMENT CHALLENGES

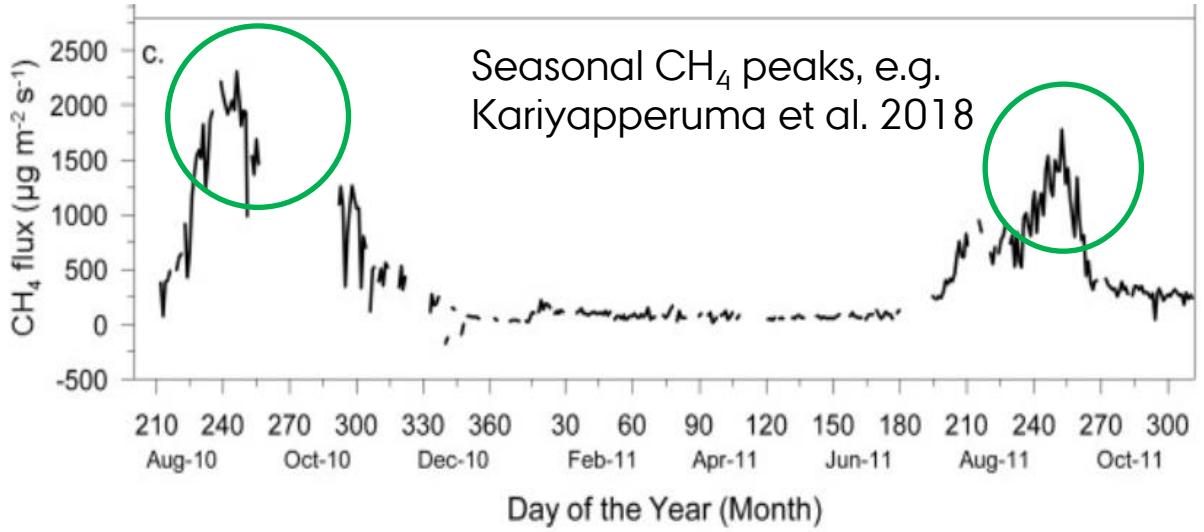
We need representative data which requires covering of:

- Short- and long-term temporal variations
- Spatial variability for e.g. area sources
- Farm-to-farm variability within a category
- Sources with complex geometry and natural ventilation
- Low emissions of e.g. N_2O and NH_3 = low ΔC

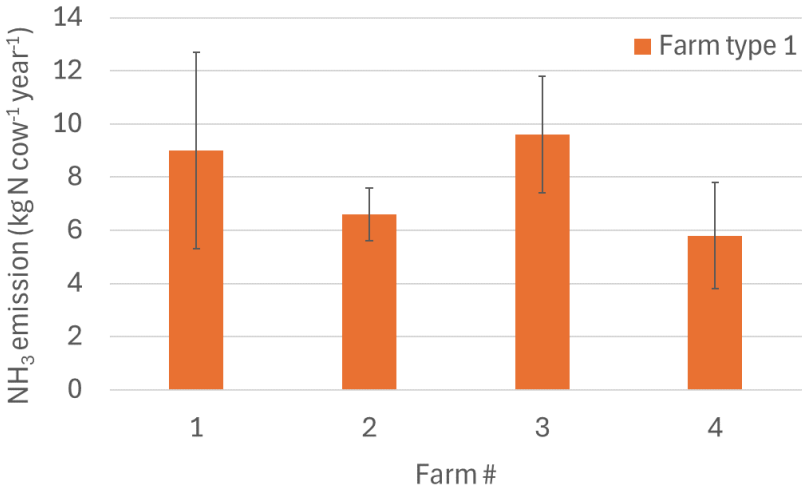
TEMPORAL VARIATION (SLURRY TANKS)



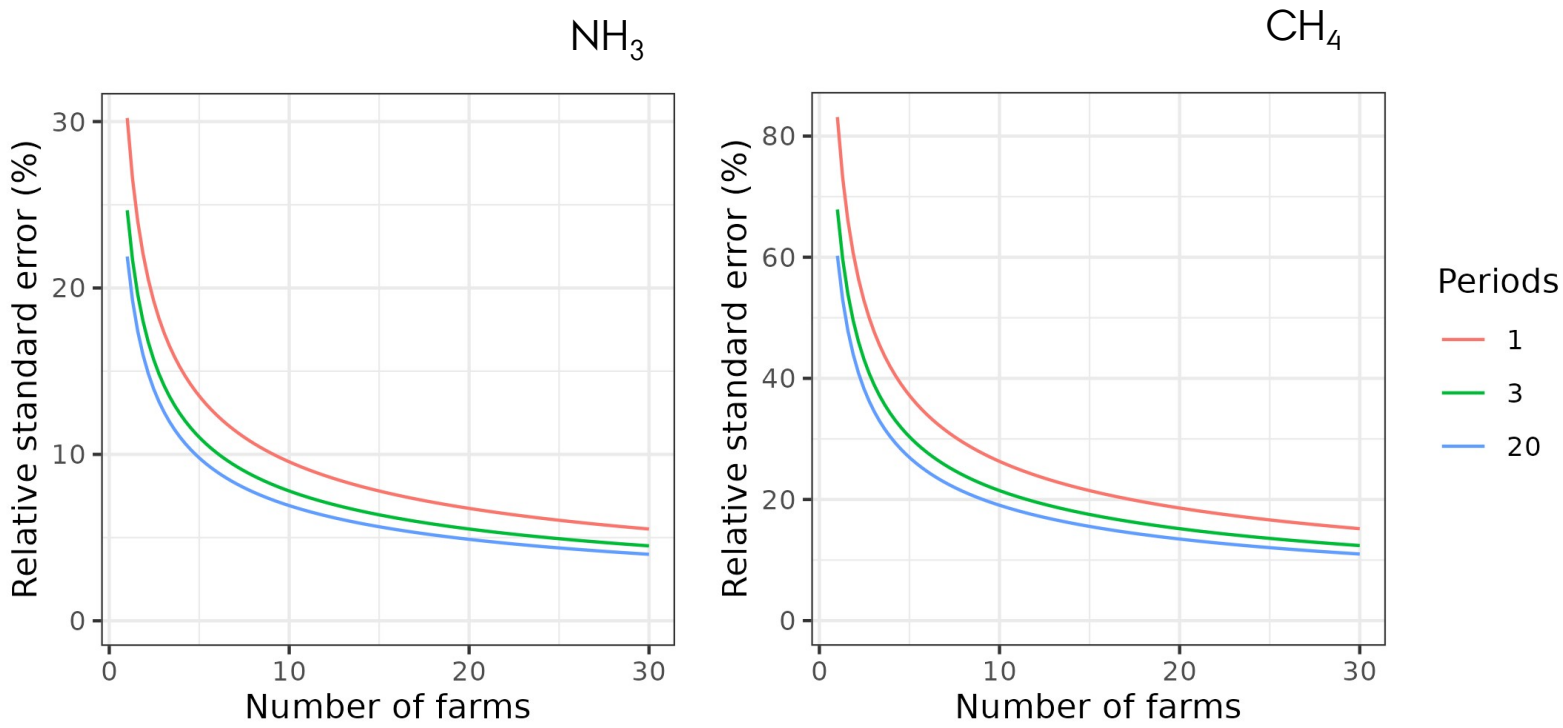
Lemes et al., 2022 AS&T



FARM-TO-FARM VARIATIONS



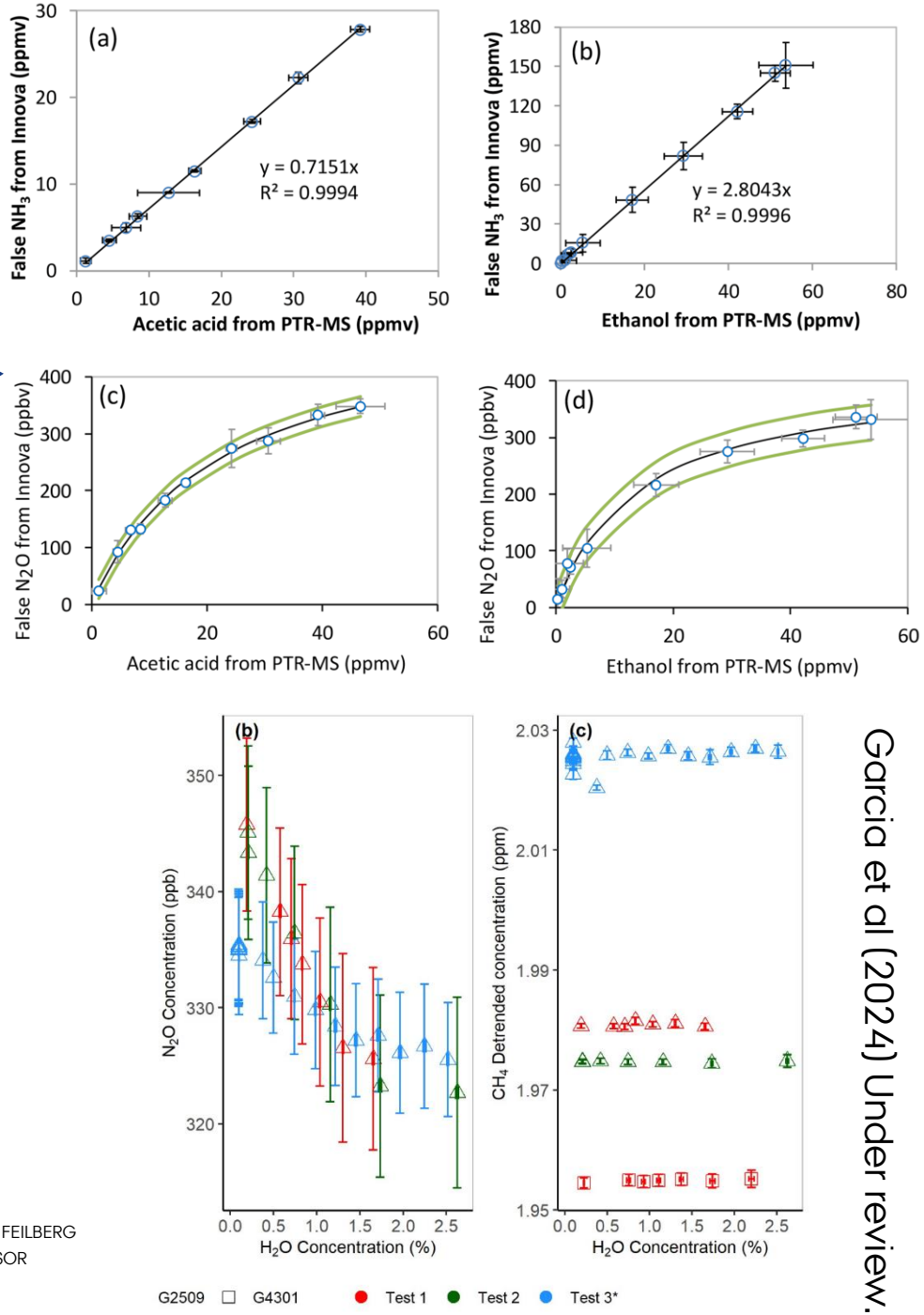
Dairy cattle farms measured 6 times over one year.
Error bars reflect annual variation.
Kai et al., 2017



Relative error of emission data vs number of farms (pig facilities).
Hafner & Dalby unpublished.

SELECTION OF INSTRUMENTS 1

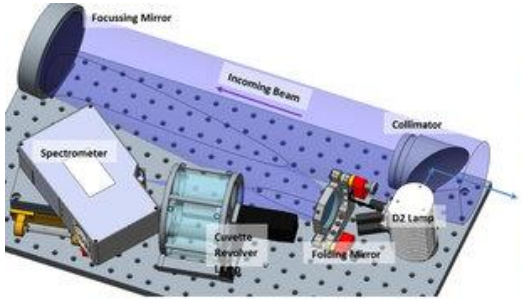
- Many gases are relevant to measure:
  - NH_3, CH_4, N_2O, CO_2…VOC, H_2S
- Sources are typically very complex
- Risk of interferences: Earlier data on agricultural emissions achieved with photoacoustic spectroscopy (PAS) using broad-range optical filters ☹
  - With laser-based CRDS interferences are negligible except for extreme cases
- Concentrations (or ΔC) from few ppb to >100 ppm



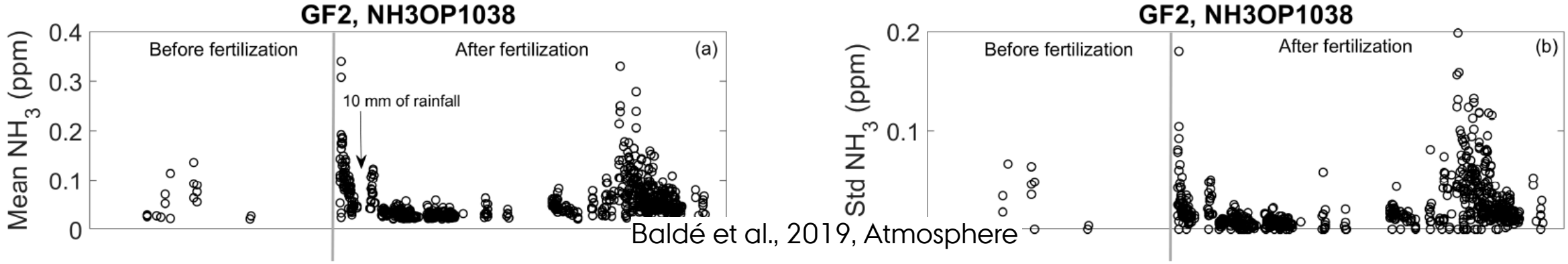
Garcia et al (2024) Under review.

SELECTION OF INSTRUMENTS 2

- We (AU) mainly have experience with closed-path measurement equipment (CRDS)
- For NH_3, heated sampling lines + high flow are needed to achieve high time resolution
- Open path alternatives:
  - Mini-DOAS (NH_3)
    not commercially available



- GasFinder (NH_3 + CH_4) – appear to be not sufficiently sensitive at low concentrations



Baldé et al., 2019, Atmosphere

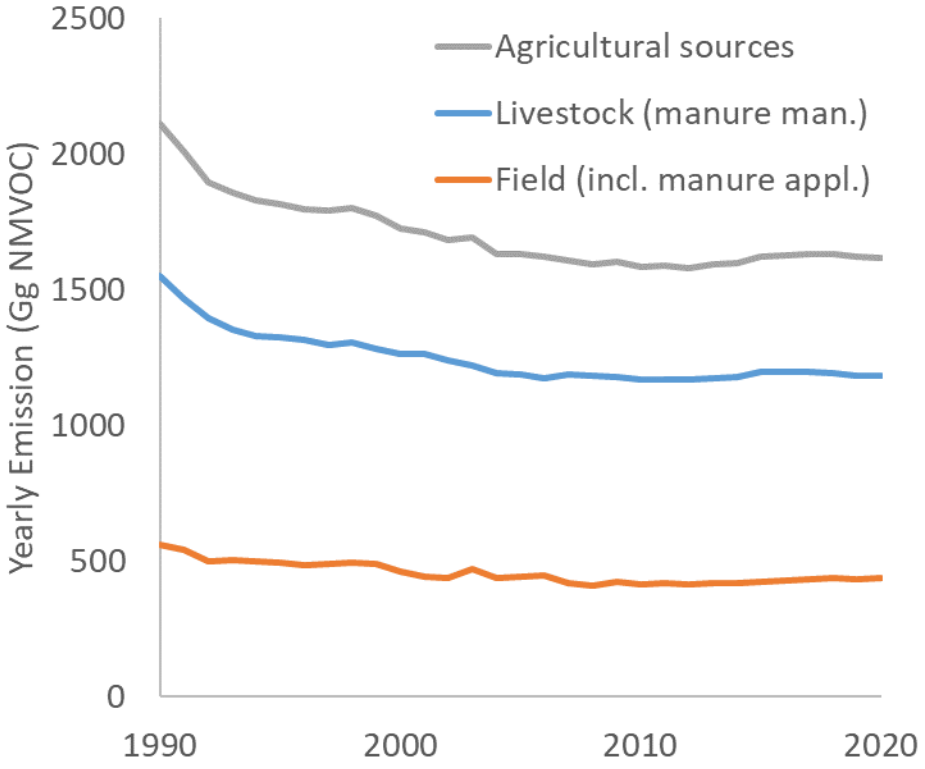
PROTOCOLS

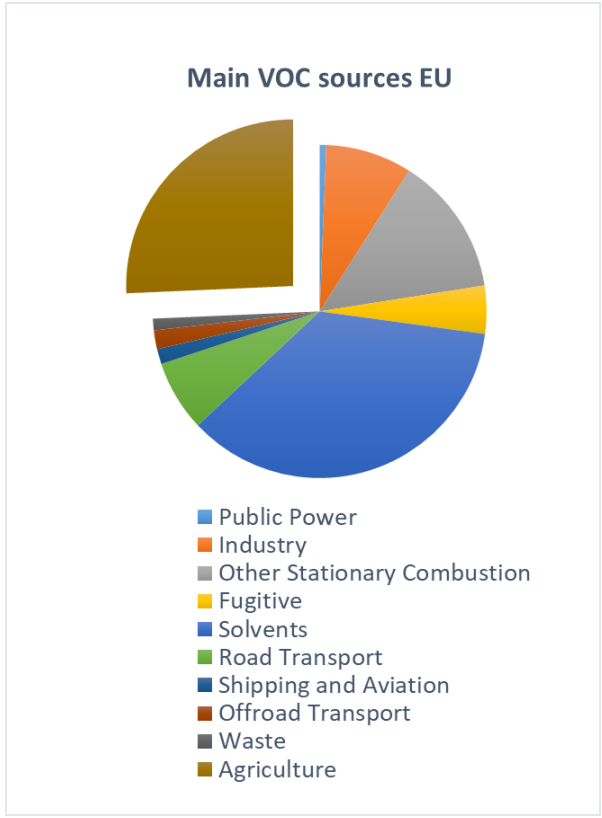
- Protocols (VERA or equivalent) exist for testing abatement technology for agriculture, but only cover NH_3 and odor

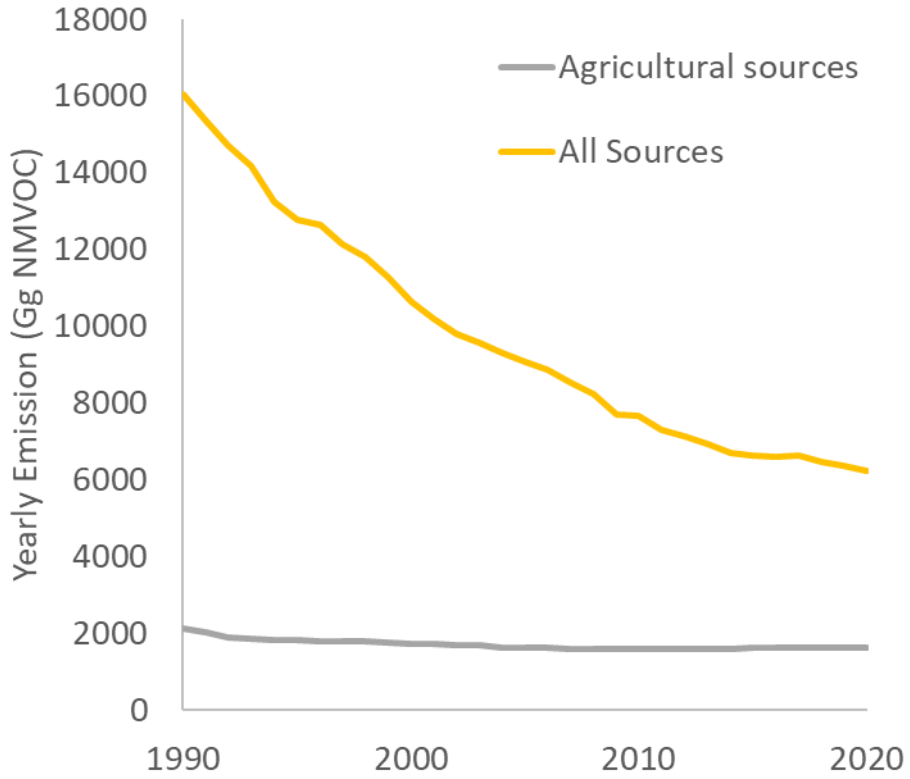
- International protocols that include GHG are needed for:
  - Achieving representative reference data for regulation and national emission inventories
  - Testing of environmental technologies including GHG
- Protocols should cover:
  - Seasonal and diurnal variation
  - Source variability
  - Quality criteria for methods and instrumentation

RELEVANCE OF AGRICULTURAL NMVOC

- NMVOC contributes to tropospheric ozone formation ⇒ accounting needed
- Recently updated emission estimates are available for agricultural sources







Data reported to CEIP/EMEP: https://www.ceip.at/webdab-emission-database/reported-emissiondata

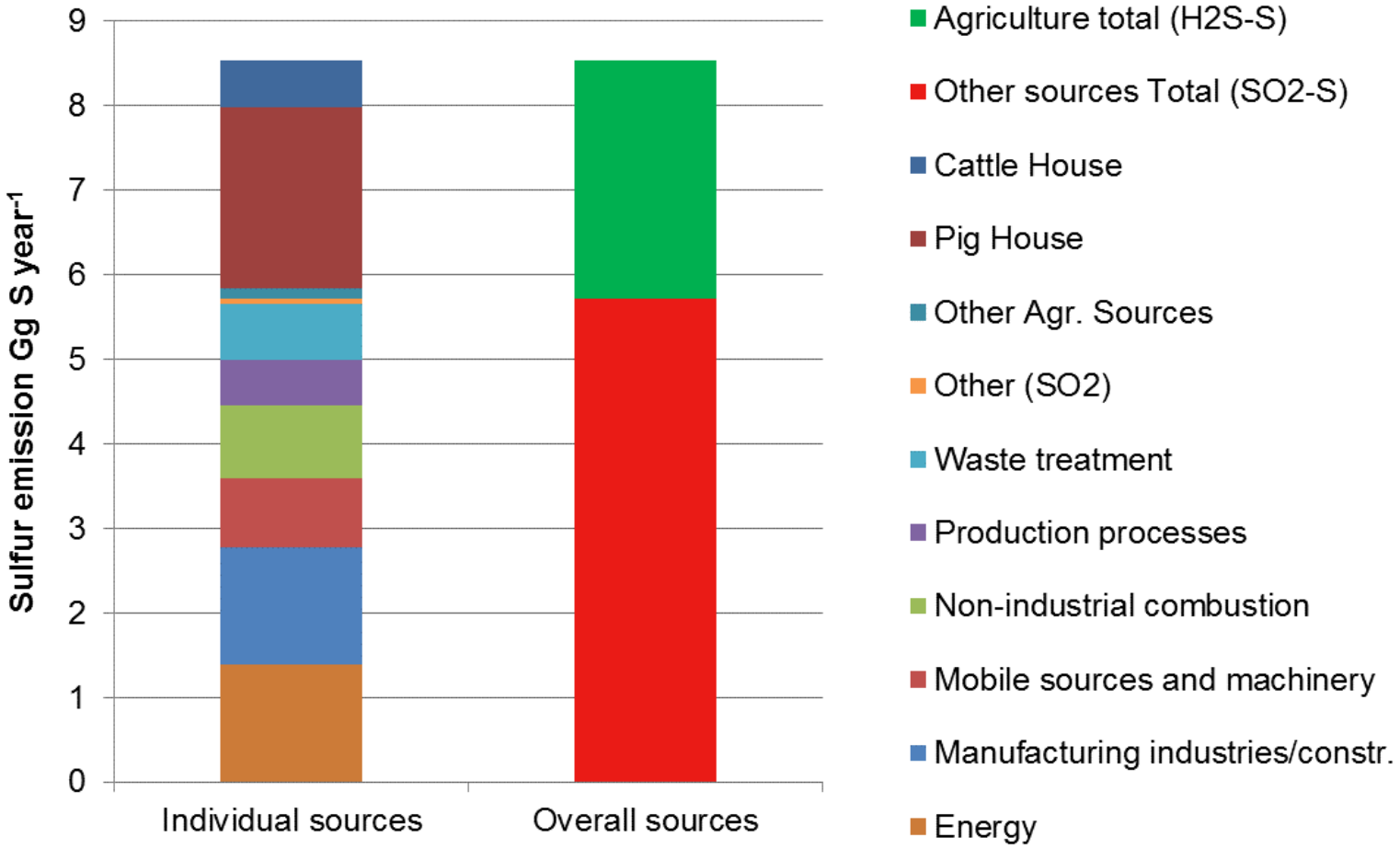
SIGNIFICANCE OF LIVESTOCK H_2S

Agricultural and other anthropogenic sources of sulfur in Denmark

See also:

Feilberg et al (2017)

Nature Communications



FUTURE RESEARCH NEEDS

- In general, a lot more data from relevant sources; systematic - unbiased - representative
- Measuring emissions from complex sources e.g.:
  - Farms with natural ventilation and access to outdoor yard
  - Grazing animals: low concentrations and high spatial/temporal variability
  - Includes also organic livestock farming
- Low-concentration emission sources of CH_4 and NH_3 e.g.:
  - Sources with efficient mitigation technologies (documentation)
  - Emissions from crops (NH_3) and wetlands (CH_4)
- Spatial and temporal variations in N_2O emissions from agricultural fields
  - Small concentration differences!

AARHUS
UNIVERSITY