Regulating agricultural ammonia emissions in Europe: Costs and benefits

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Introduction

- Air pollution, in particular fine particulate matter (PM2.5), has been associated with many adverse health impacts.
- Exposure to PM2.5 is considered responsible for 4.55 million excess deaths annually worldwide, of which 274,000 per year are reported for EU (Lelieveld et al., 2018).
- Recent studies have revealed a large contribution of agricultural emissions to PM2.5 pollution in many European countries
- Ammonia (NH_3) emissions, which originate for 96% from agricultural activities, significantly contributes to the formation of PM2.5
- The regulation of agricultural ammonia emissions has been considered as one of the most effective control strategies for reducing PM2.5 in Europe

Regulation of air pollution

- Anthropogenic air pollution emissions have been significantly reduced over the past 20 years in Europe (Directive 2001/81/EC); from 2005 to 2016:

  →sulphur dioxide (SO2): -70%

  →nitrogen oxides (NOx): -37%

  → non-methane volatile organic compounds (NMVOC):-28%

  →PM2.5: -21%

- Agriculture is the sector in which air pollutant emissions have decreased least

  →NH3: -2%

Policies for controlling air pollution from agriculture

- Little support for ammonia reduction has been provided by the Common Agricultural Policy (CAP) (European Commission, 2013).
- However, the current reform of the legislative framework of the CAP for the period 2021-2027 identifies the improvement of air quality as a top priority.

  → Agriculture was a focus topic of the first Clean Air Forum (2017) and one of the three themes of the second Clean Air Forum (2019).

- The current CAP includes a number of emission-reducing support measures
  - RDP measure 'Investments in physical assets' (e.g., investments in low emission manure storage and spreading facilities)
- Despite the availability of technical measures to mitigated NH3 emissions, yet little progress has been made in reducing agricultural emissions.

Directive 2016/2284/EU

- The Directive 2016/2284/EU sets national reduction commitments for EU countries for the five most important atmospheric pollutants

  →from 2020 to 2029, NH_3 emissions need to be reduced by 6% across the EU-28 compared to 2005

  →from 2030 onwards, NH_3 emissions need to be reduced by 19%

Objectives

- to estimate the costs and benefits of regulating NH3 emissions for the compliance of the agricultural sector of EU-countries with the commitments of the National Emission Ceilings Directive 2016/2284/EU

  → to estimate the required national NH3 emission reductions across the EU-28

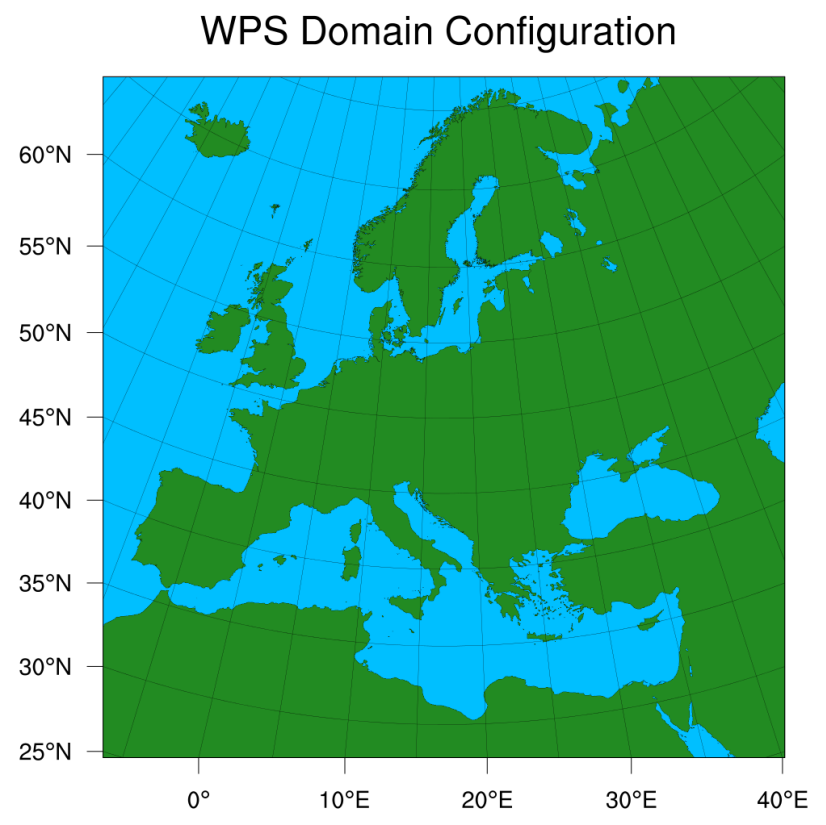
  → to model the effects of these reductions on PM2.5 concentrations over Europe

  → to estimate and monetize the resulting reduced premature mortality

  → to assess the costs of the required NH3 emission abatement options.

Atmospheric chemistry model: WRF/Chem

- **Two annual simulations of WRF/Chem were performed:**
  - i. **one with the standard emission inventory available in WRF/Chem**
  - ii. **one with the country-based NH3 emission reductions according to the national emission reduction commitments from 2020 to 2029**
- **The PM2.5 concentrations and the impact of reducing ammonia emissions are assessed for each of the 16 EU countries and over the full domain**



Health impact

- The annual mean PM2.5 concentrations estimated from the two simulations of WRF/Chem are used to estimate reduced mortality rates for a range of related diseases and age groups

  →health effects of PM2.5 related to ischaemic heart disease, cerebrovascular disease, lower respiratory tract infections, chronic obstructive pulmonary disease and lung cancer.

  →The respective burden of disease is analyzed for the following age groups: below 5 years, 5–14, 15–29, 30–49, 50–69 and 70 and older.

Economic valuation of mortality

- The Value of Statistical Life (VLS) was applied to calculate the benefits of reducing ammonia emissions from agriculture.
- The VLS is the marginal rate of substitution between wealth and mortality risk:

$$VSL = \frac{\partial WTP}{\partial p}$$

- We used the VSL base value of 3 million USD (in 2005-USD) derived by the OECD (2012) meta-analysis study
- The VSLs for the individual countries (EU and non-EU) were estimated for the year 2016 adjusting for differences in income and economic growth:

$$VSL_{i,2016} = VSL_{OECD,2005} \times \left(\frac{Y_{i,2005}}{Y_{OECD,2005}}\right)^{\beta} \times \left(1 + \%\Delta P_{i,2005-2016} + \%\Delta G_{i,2005-2016}\right)^{\beta}$$

- The annual economic value (EV) of reduction in NH3 emissions is calculated as follows:

$$EV(L_i) \times (VSL_i)$$

Costs of ammonia emission abatement options

- A set of measures for reducing ammonia emissions is included in Directive 2016/2284/EU
- Oenema et al. (2012) using the Greenhouse gas – Air pollution INteractions and Synergies (GAINS) model has estimated the cost of NH_3 emission abatement options in €/kg nitrogen (kg N) removed per year
- Here, we analysed the cost of two NH_3 emission abatement options:

  → low nitrogen feed

  → low emission animal housing abatement option

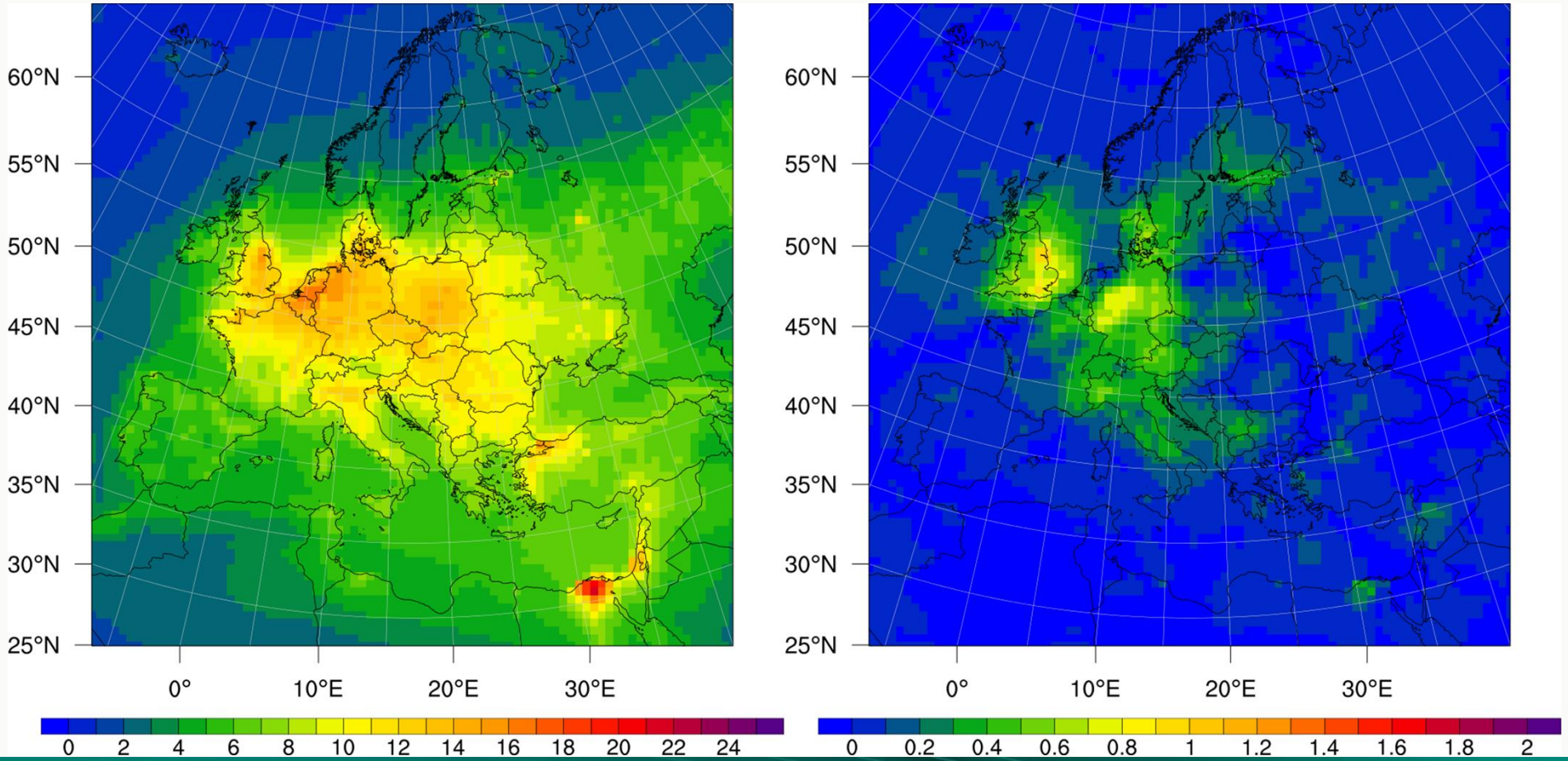
Required national NH_3 emission reductions across EU-28 countries

- **We calculated that 16 out of the 28 EU member states exceeded their 2020 NH_3 emission ceilings in 2016**

  → **The highest deviations from the 2020 emission commitment level occurred in Latvia (15%), Germany, Estonia and the UK (12%), Sweden (11%) and Finland (10%)**

Air quality impact

- The distribution of the differences in PM2.5 concentrations from the application of NH3 abatement options shows a PM2.5 maximum over central-western Europe, especially over Germany and UK



Health assessment

- **The most positively affected countries in terms of reduced premature mortality compared to the control run, are mainly located in Scandinavia.**

Countries	% reduction in premature mortality
Finland	13.1
Sweden	9.2
Norway	9.0
Estonia	6.1
Ireland	5.4
United Kingdom	3.9
Denmark	2.5
Austria	2.3
Germany	2.2
Italy	2.2
Switzerland	2.2
Luxembourg	2.1
Portugal	2.1

- **In terms of absolute values of excess deaths, Germany is expected to have the largest benefit (930) followed by UK (928) and Italy (448).**
- **Changes in excess mortality do not follow a linear relationship with PM2.5 concentrations**
- **The IER functions tend to "flatten" towards higher PM2.5 concentrations, and air pollution control measures can be particularly effective at relatively low levels (e.g., Scandinavian countries)**

Costs & benefits of meeting the national emission reduction commitments for the period 2020-2029

	Cost of low nitrogen feed (M€)	Cost of low emission animal housing (M€)	Economic benefit of reducing NH_3 emissions (M€)
Austria	1.8	84.3	319.1
Bulgaria	0.3	12.6	101.2
Denmark	3.1	146.6	212.3
Estonia	0.5	24.8	97.6
Finland	1.1	53.9	295.2
France	12.2	569.5	848.8
Germany	31.9	1,497.2	3,652.4
Hungary	2.6	119.9	165.0
Ireland	2.5	116.9	173.5
Latvia	0.9	41.7	26.0
Luxembourg	0.2	10.7	25.2
Portugal	0.5	24.2	113.8
Slovakia	0.2	7.9	92.4
Spain	7.0	329.6	182.5
Sweden	2.1	98.6	648.4
United Kingdom	12.8	599.3	3,416.2
EU-16	**79.7**	**3,737.7**	**10,369.7**
EU-28	**79.7**	**3,737.7**	**13,488.2**
EU-28 and neighbouring non-EU countries	**79.7**	**3,737.7**	**14,837.5**

Conclusions

- Our analysis indicates that meeting the requirements of the air quality regulatory framework (Directive 2016/2284/EU) can generate large health and economic benefits for the EU countries implementing the measures but also for the wider region.

  → **More ambitious reduction commitments for ammonia emissions could be applied by EU-28 countries with relatively minimal costs.**

- The exceedance of economic benefits over farmers' abatement costs may indicate the need of transferring back part of the societal benefit of reduced ammonia emissions to the farmers in the form of investment support for the abatement measures.

  → **The CAP through RDP measures could strongly contribute to meeting those emission reduction commitments.**

- A better integration of agricultural and air quality policies could further lead to reduced air pollution and health impacts in Europe.

References

European Commission (2013) Clean air policy package - commission staff working document. Impact assessment (SEC(2005) 1133)/Annex to COM(2005) 446/447

Lelieveld J, Haines A, Pozzer A (2018) Age-dependent health risk from ambient air pollution: a modelling and data analysis of childhood mortality in middle-income and low-income countries. Lancet Planet Health 2(7): e292–e300

Oenema O, Velthof G, Klimont Z, Winiwarter W (2012) Emissions from agriculture and their control potentials. IIASA TSAP report 3, Version 2.1

More information

Giannakis, E., Kushta, J., Bruggeman, A. and Lelieveld, J., 2019. Costs and benefits of agricultural ammonia emission abatement options for compliance with European air quality regulations. Environmental Sciences Europe, 31(1), p.93, https://doi.org/10.1186/s12302-019-0275-0