Inter-industry linkages and air pollution: Evidence from the European Union

Giannakis, E. & Kushta, J.

Energy Environment and Water Research Center, The Cyprus Institute

20th Global Conference on Environmental Taxation

Limassol
September 25-28, 2019

THE CYPRUS INSTITUTE

EEWRC

Introduction

- Air pollution, in particular fine particulate matter (PM2.5), has been associated with many 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).
- Significant excess death rates are related to fossil energy use, as combustion emissions from traffic, power generation, and industry
- Recent studies have revealed the contribution of agricultural (Giannadaki et al., 2018) and shipping (Aulinger et al. 2016) emissions to PM2.5 pollution 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%

  → NH3: -2%

- The Directive 2016/2284/EU sets national reduction commitments for EU-28 from 2030 for the five most important atmospheric pollutants compared to 2005

SO_2	NOx	NMVOC	NH_3	PM2.5
79%	63%	40%	19 %	49 %

Objectives

- to assess the direct and indirect contribution of the production sectors of the EU-28 countries to the emissions of air pollutants
- to assess the impact of economic growth on air pollution and human health in the EU-28, accounting for all monetary inter-industry transactions

    → combination of environmentally extended input-output models and atmospheric chemistry models

Environmentally-extended input-output models (EE-IOA)

- Input-output analysis (IOA) is a quantitative technique for studying the interdependence of production sectors in an economy over a stated time period

  → The direct and indirect generation of economic output due to changes in sectoral final demand

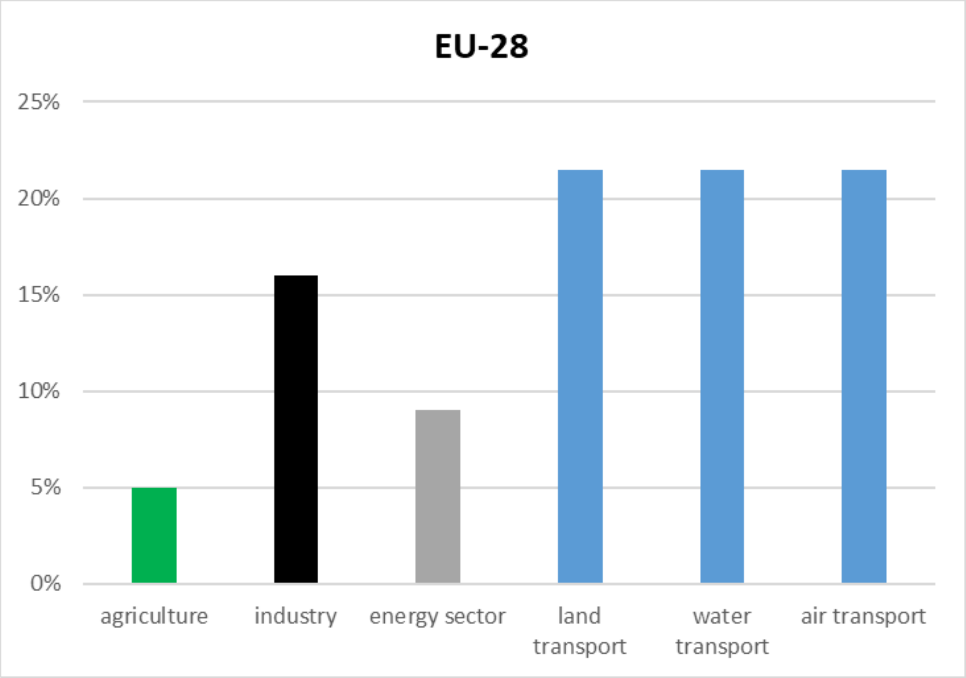
- The extension of an IOA model to EE-IOA model involves the use of an exogenous vector of air pollutant emissions

  → The direct and indirect pollutant emissions due to change in sectoral final demand

Economic growth rates (EU Reference 2016)

We developed an EEIO model for the EU-28 economy & 28 individual models for each of the member state

Growth rates of EU-28 main economic sectors (2015-2030)



Economic Sectors	NACE Classification
Agriculture	A01, A03
Industry	C10-33
Electricity, gas & water	D, E36--39
Land transport	H49
Water transport	H50
Air transport	H51

NACE statistical classification of economic activities in the EU

Emission Database Classification for Global Atmospheric Research (EDGAR)

Atmospheric chemistry model: WRF/Chem

- The Weather Research and Forecast model coupled with the chemistry module (WRF/Chem) was used in this study to assess the effects of economic growth on PM2.5 concentrations over Europe.
- **Eight** annual simulations of WRF/Chem were performed:
  - i. **one** with the standard emission inventory available in WRF/Chem
  - ii. **seven** with the country-based air pollutants emission increases due to the growth of the main economic sectors towards 2030
    1. agriculture
    2. industry
    3. energy
    4. land transport
    5. water transport
    6. air transport
    7. All six sectors (ALL sectors)
- The PM2.5 concentrations and the impact of economic growth are assessed for each of the 28 EU countries

Health impact

- The annual mean PM2.5 concentrations estimated from the eight simulations of WRF/Chem are used to estimate increased 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.

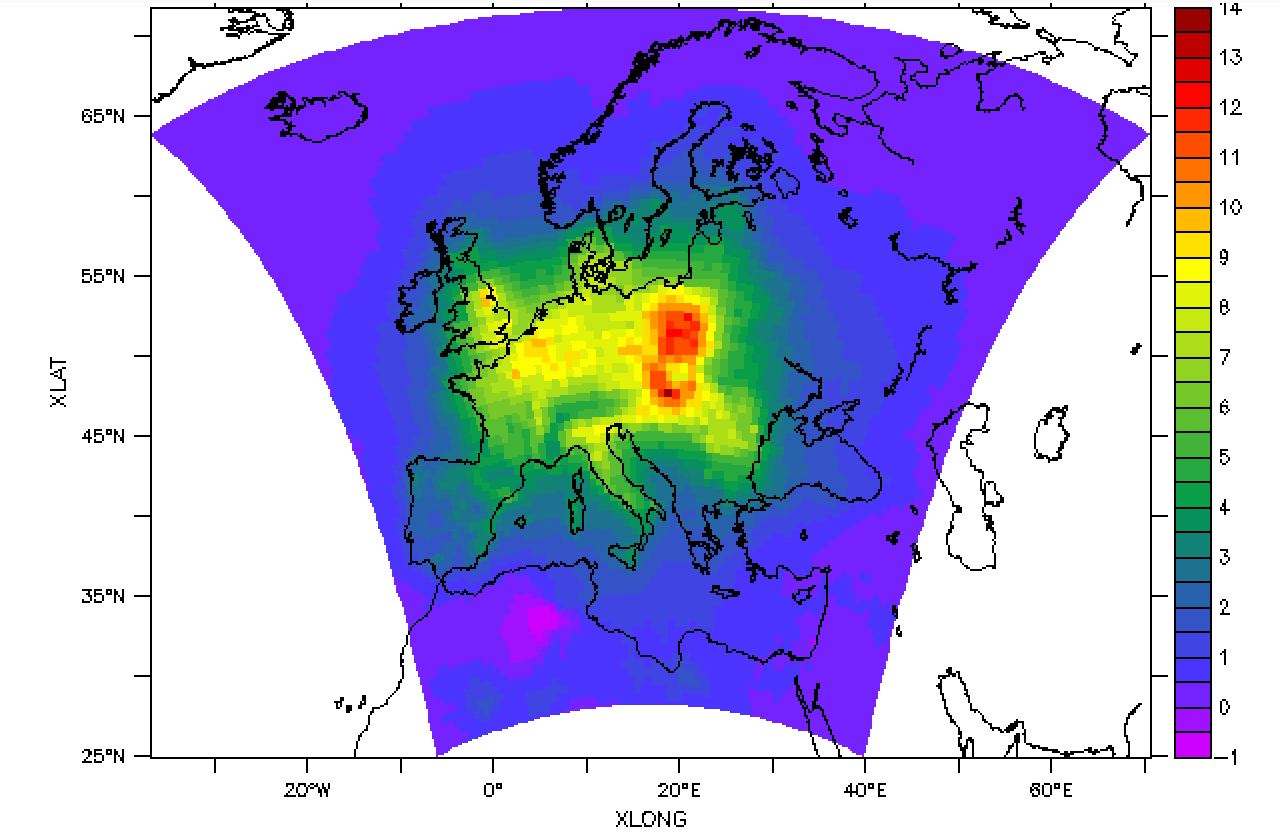
  → the respective burden of disease is analyzed for the following age groups: below 5 years, 5–14, 15–29, 30–49, 50–69 and 70 and older.

Air pollutant emission multipliers for EU-28 (tn/M€)

	Economic output	SOx	NOx	NH3	NMVOC	CO	PM2.5	PM10
Agriculture	2.08	0.43	3.97	11.36	4.39	4.82	0.46	1.34
Forestry	1.83	0.09	1.07	0.04	3.19	3.72	0.13	0.18
Industry	2.19	2.83	8.65	3.99	3.16	5.43	0.64	1.08
Electricity, gas and water	2.12	3.52	3.72	0.71	0.77	1.57	0.20	0.33
Construction	2.17	0.30	1.03	0.24	0.46	0.70	0.09	0.16
Trade	1.82	0.81	2.78	1.27	1.05	1.60	0.21	0.35
Land transport	1.90	0.36	3.70	0.30	0.61	2.05	0.19	0.30
Water transport	2.00	8.50	23.71	0.04	1.35	3.90	1.78	2.03
Air transport	2.12	0.24	3.78	0.03	0.19	1.45	0.09	0.11
Accommodation and Food Services	1.89	0.10	0.35	0.04	0.06	0.17	0.03	0.03
Banking - Financing	1.83	0.61	1.94	0.57	0.49	0.86	0.14	0.21
Real estate	1.48	0.39	1.22	0.21	0.25	0.49	0.09	0.12
Public administration	1.50	0.10	0.30	0.05	0.08	0.24	0.02	0.03
Education	1.33	0.05	0.20	0.03	0.05	0.13	0.01	0.02
Health	1.54	0.02	0.08	0.01	0.02	0.06	0.01	0.01
Other Services	1.81	3.81	12.28	1.73	1.93	4.21	0.84	1.12

Economic growth and air pollution

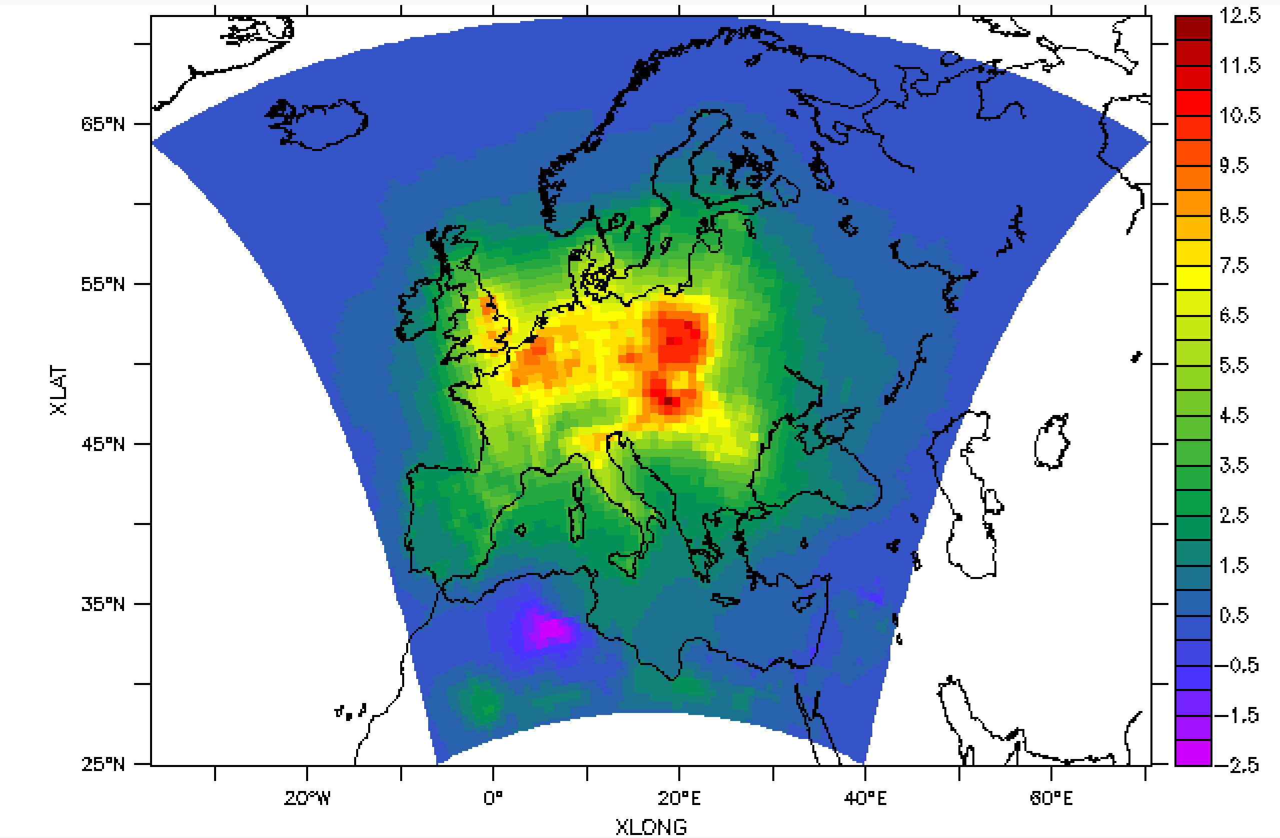
ALL Sectors Scenario vs Baseline: Change in PM2.5 concentrations



The distribution of the differences in PM2.5 concentrations shows a peak of PM2.5 over Poland, Hungary and Central Europe

Economic growth of industry and air pollution

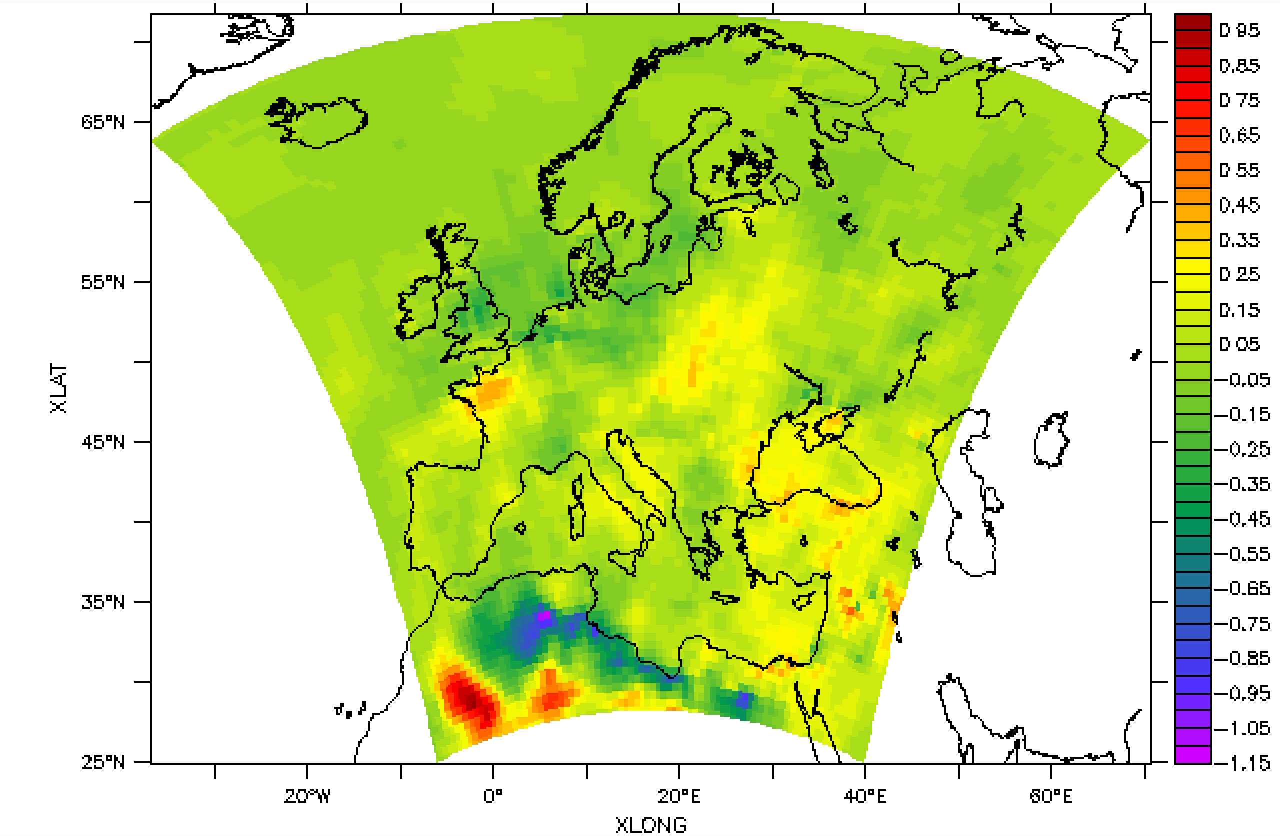
Industry Scenario vs Baseline: Change in PM2.5 concentrations



The distribution of the differences in PM2.5 concentrations shows a peak of PM2.5 over Poland, Hungary and Central Europe

Economic growth of energy sector and air pollution

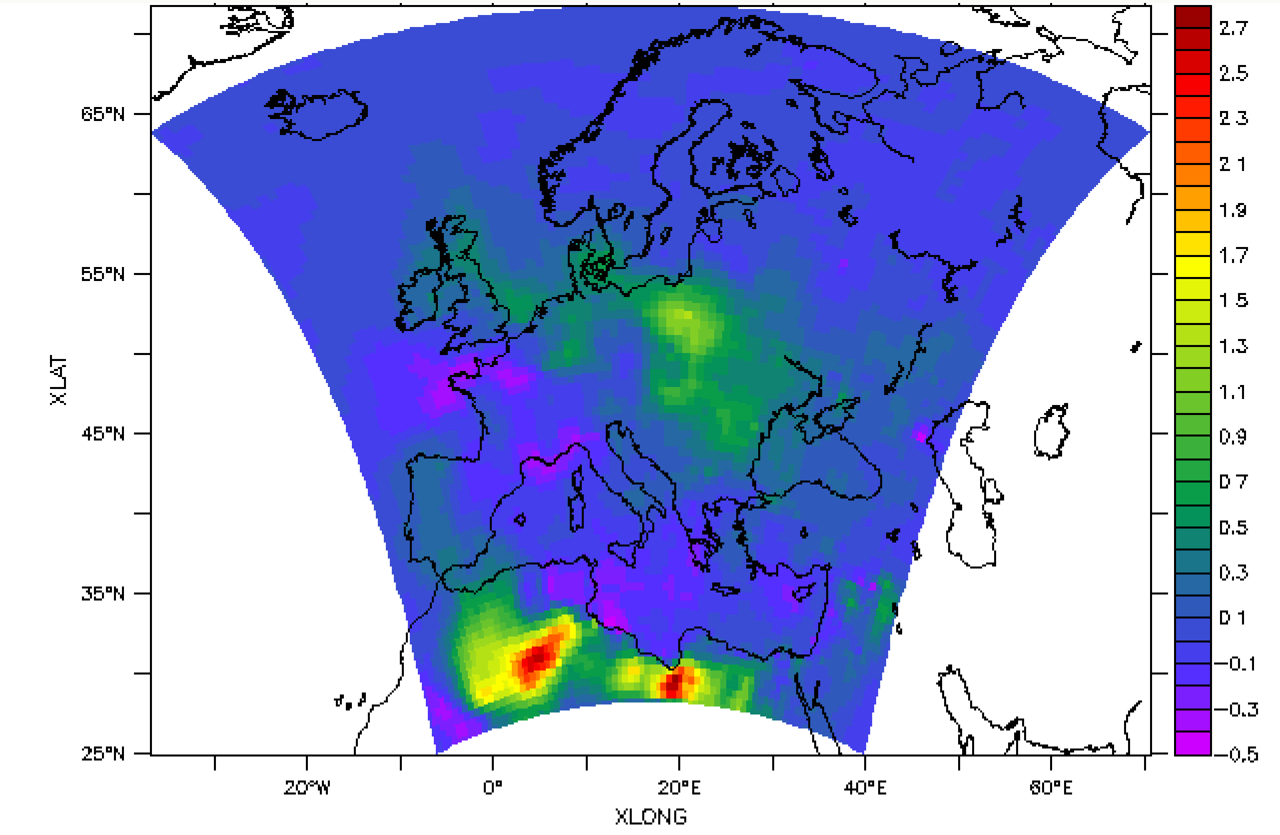
Energy Scenario vs Baseline: Change in PM2.5 concentrations



- The differences in PM2.5 concentrations are small
- PM2.5 concentrations show a peak of over France

Economic growth of agriculture and air pollution

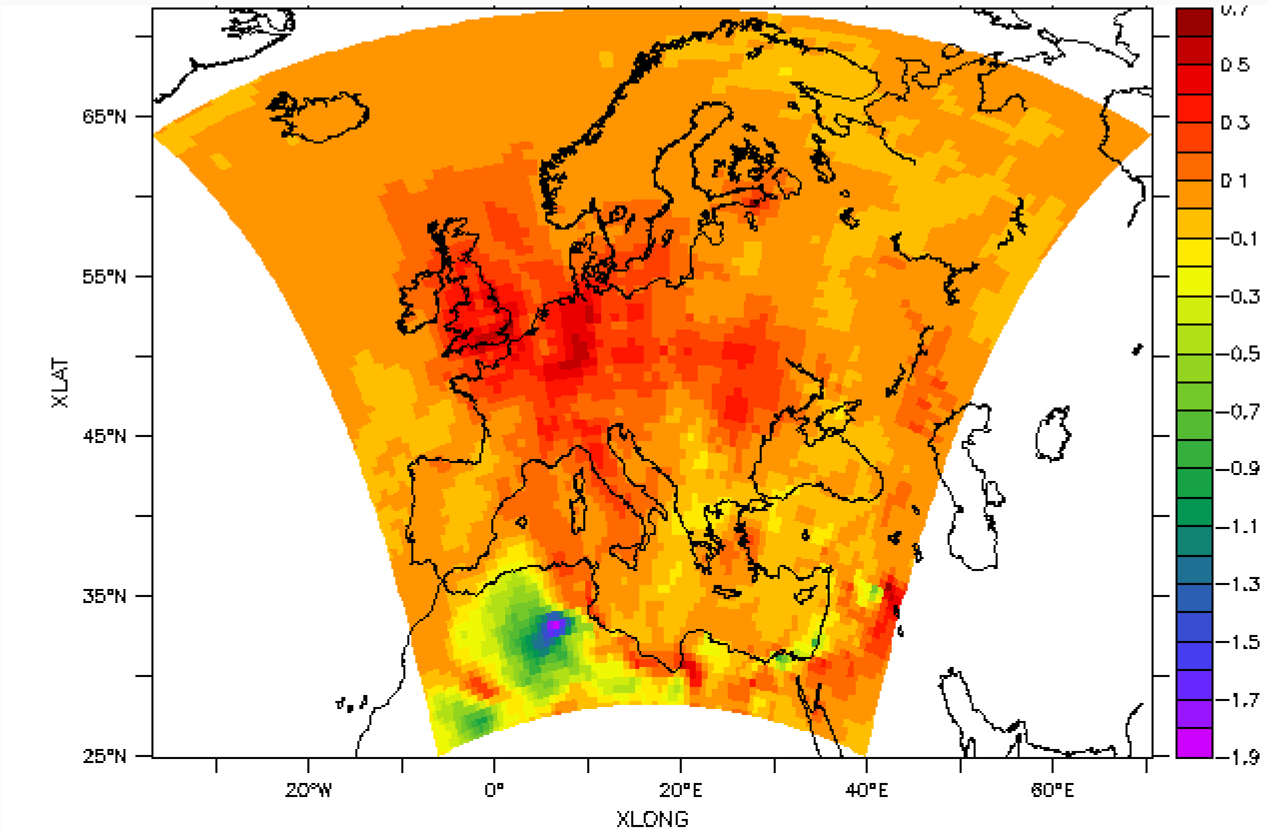
Agriculture Scenario vs Baseline: Change in PM2.5 concentrations



The distribution of the differences in PM2.5 concentrations shows a peak of PM2.5 over Romania and Poland

Economic growth of land transport and air pollution

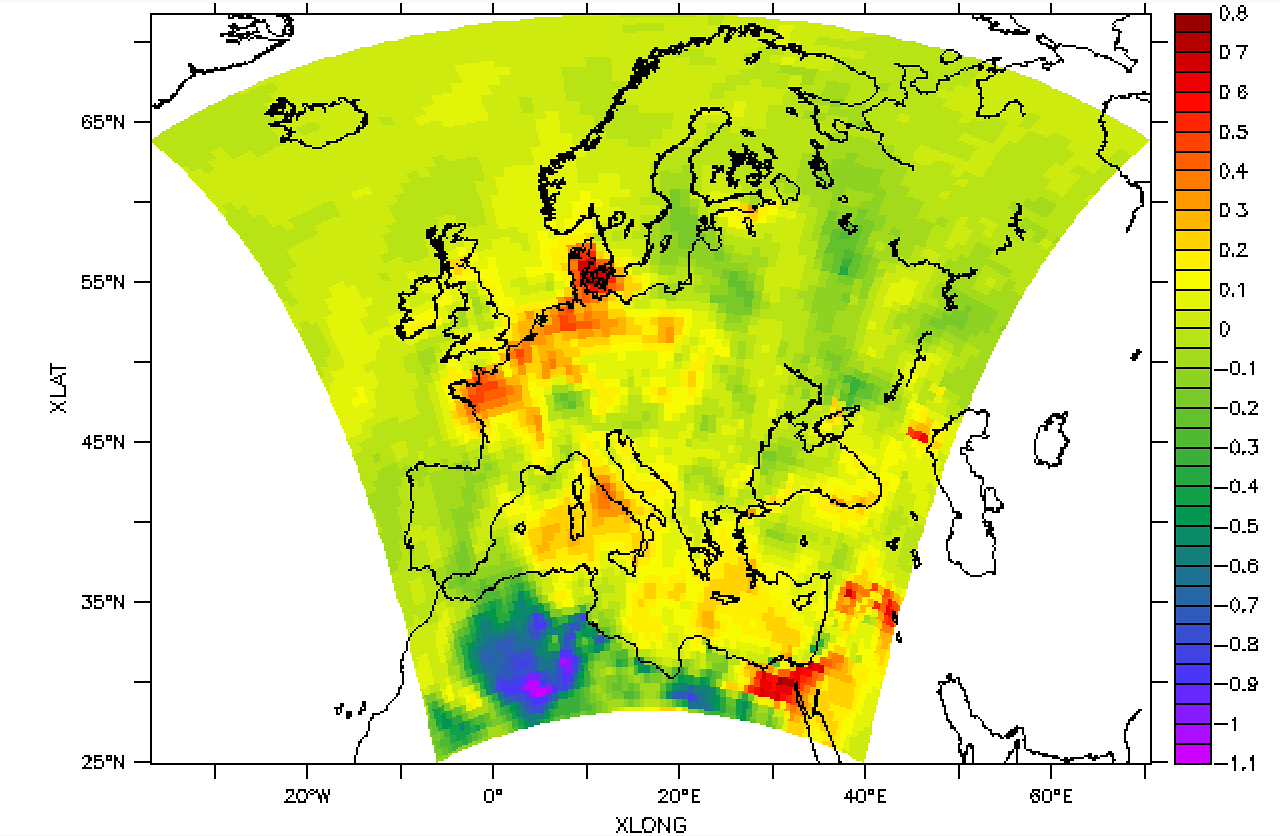
Land Transport Scenario vs Baseline: Change in PM2.5 concentrations



The distribution of the differences in PM2.5 concentrations shows a peak of PM2.5 over Italy, UK and Central Europe

Economic growth of water transport and air pollution

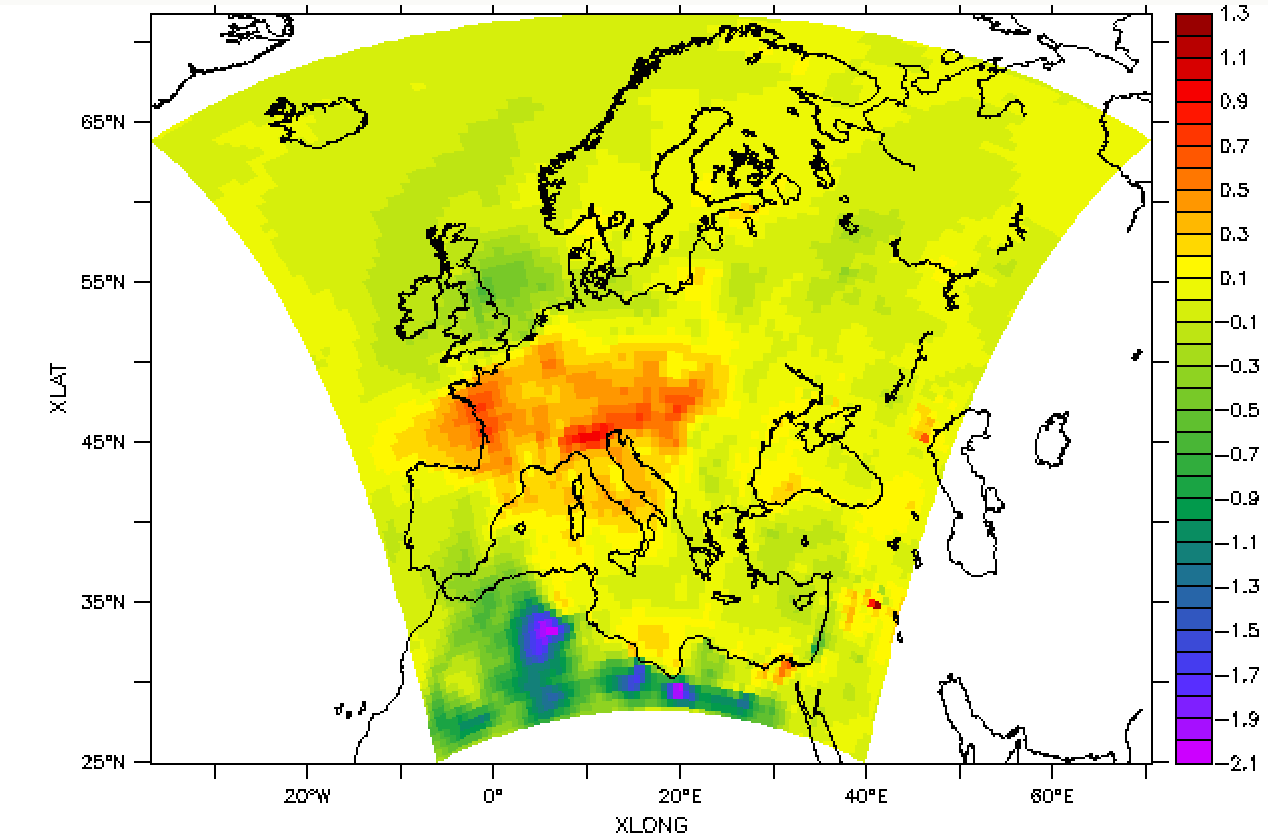
Water Transport Scenario vs Baseline: Change in PM2.5 concentrations



The distribution of the differences in PM2.5 concentrations shows a peak of PM2.5 over North Sea and Mediterranean countries

Economic growth of air transport and air pollution

Air Transport Scenario vs Baseline: Change in PM2.5 concentrations



The distribution of the differences in PM2.5 concentrations shows a peak of PM2.5 over central-western Europe

Health impact assessment: excess premature mortality (%) relative to control PM2.5 concentrations

Member states	ALL Sectors	Industry	Energy	Agriculture	Land	Water	Air
Austria	27%	26%	0.5%	0.7%	0.8%	0.3%	2.1%
Belgium	24%	24%	-0.4%	0.3%	0.8%	0.9%	0.8%
Bulgaria	15%	13%	0.3%	1.0%	0.1%	0.0%	-0.1%
Croatia	22%	21%	0.4%	0.8%	0.5%	0.2%	1.8%
Cyprus	4%	4%	1.1%	-0.6%	-0.1%	0.7%	-1.0%
Czechia	24%	22%	0.0%	0.5%	0.9%	0.2%	1.0%
Denmark	25%	23%	-0.3%	2.2%	0.9%	2.3%	-0.4%
Estonia	20%	19%	0.5%	0.8%	0.8%	0.6%	0.9%
Finland	32%	27%	0.7%	1.0%	1.7%	0.3%	1.8%
France	26%	25%	0.5%	-0.6%	1.0%	0.8%	1.8%
Germany	23%	22%	-0.2%	1.0%	1.2%	0.7%	0.7%
Greece	10%	10%	-0.1%	-0.5%	-0.1%	0.6%	0.1%
Hungary	27%	25%	0.5%	2.1%	0.3%	0.3%	1.9%
Ireland	24%	21%	0.2%	3.1%	1.7%	1.1%	-2.3%
Italy	23%	22%	0.5%	-0.1%	1.0%	0.8%	2.0%
Latvia	18%	17%	-0.2%	0.0%	0.1%	-0.7%	-0.2%
Lithuania	18%	17%	0.4%	0.8%	0.3%	-0.4%	0.2%
Luxembourg	24%	24%	-0.2%	1.2%	1.3%	1.0%	1.6%
Malta	10%	11%	-0.1%	-1.3%	0.4%	0.9%	-0.1%
Netherlands	21%	21%	-0.7%	0.9%	0.8%	1.0%	-0.1%
Poland	26%	24%	0.3%	2.4%	0.7%	0.4%	0.4%
Portugal	16%	14%	0.8%	1.5%	0.3%	-0.2%	-0.3%
Romania	20%	19%	0.6%	2.0%	0.6%	0.0%	0.3%
Spain	25%	23%	0.6%	0.9%	0.3%	-0.5%	-0.1%
Sweden	34%	31%	-0.4%	1.6%	1.5%	0.3%	0.5%
UK	25%	24%	-0.5%	1.0%	1.8%	0.4%	-1.1%
EU-28	**23%**	**21%**	**0.1%**	**1.0%**	**0.9%**	**0.5%**	**0.6%**

Conclusions

- The economic growth of industry sector creates the highest adverse air quality and human health effects
- In clean environments (e.g., Finland, Sweden), i.e., regions with PM2.5 concentrations less than 10 μg/m^3, a very small increase in pollution increases mortality dis-proportionally to polluted countries, i.e. countries with PM2.5 around 20 μg/m^3
- Formulating air pollution taxes and subsidies should take into account:
  - Health effects
  - Inter-industry linkages