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science for global insight

An outlook for global air quality

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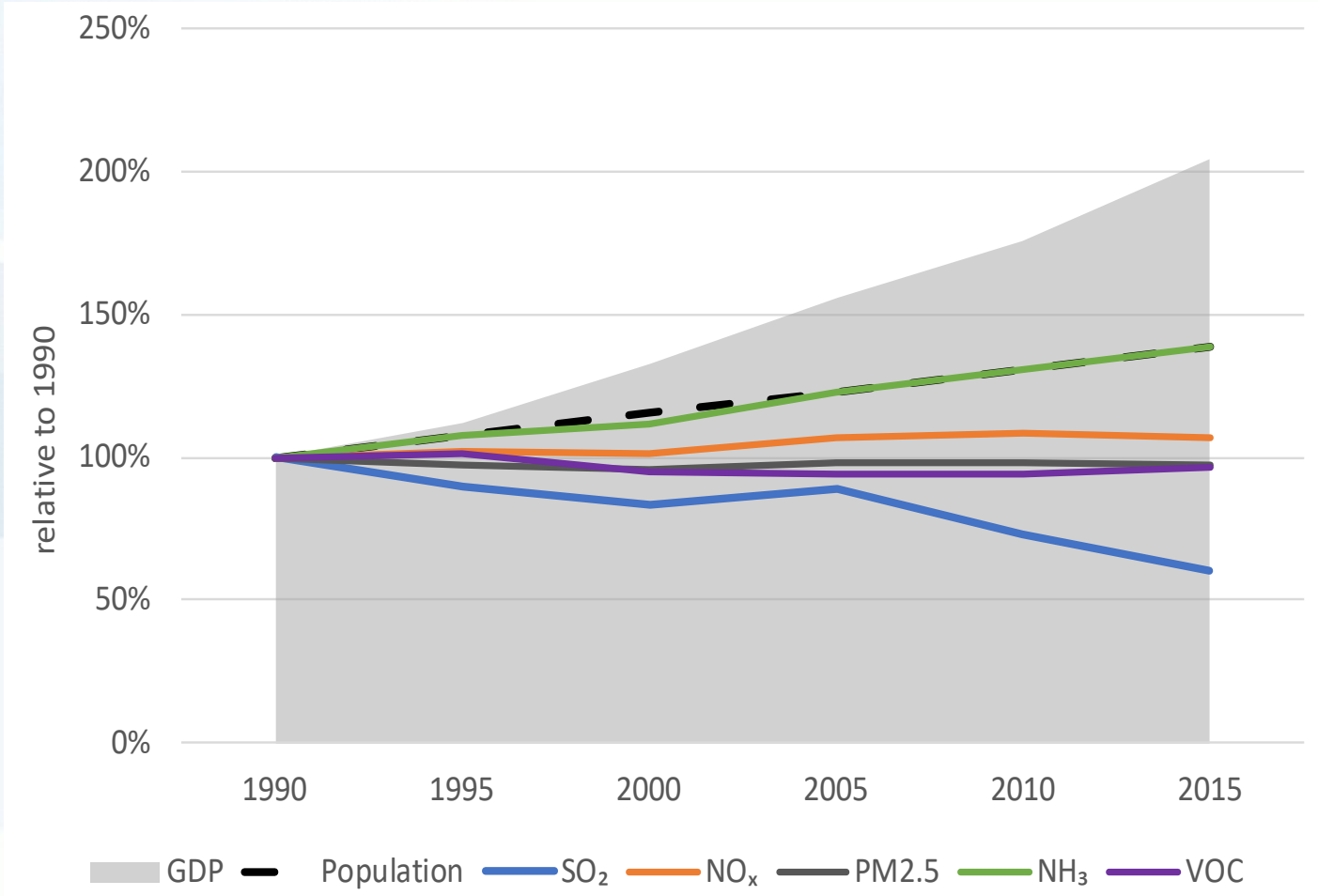
Global trends of energy-related emissions of air pollutants have decoupled from GDP development

Trends of global GDP, population and PM2.5 precursor emissions from anthropogenic sources, 1990-2015

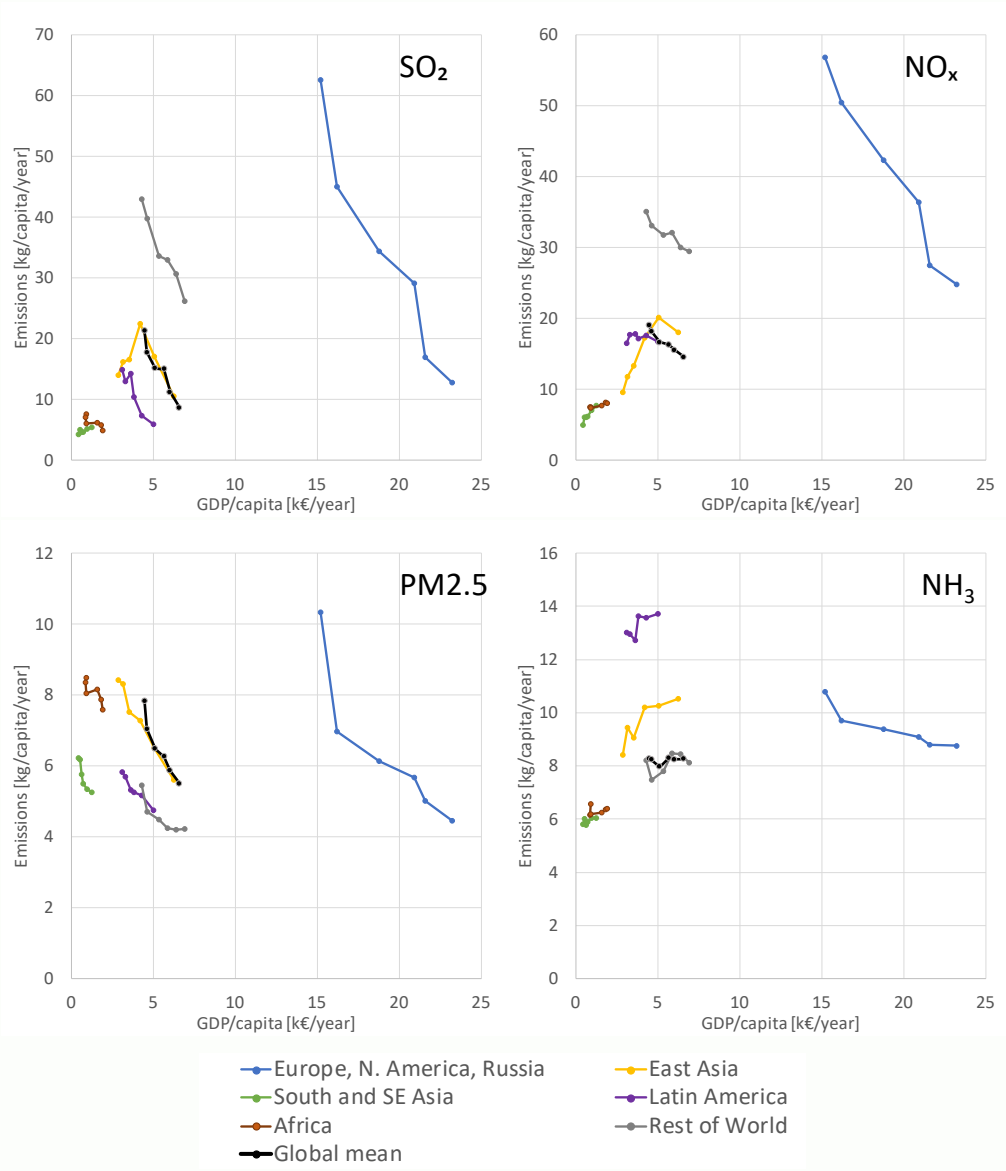


Energy-related per-capita emissions are now declining in all world regions

- Data from all world regions support - for energy-related pollutants - the 'environmental Kuznets curve' hypothesis, suggesting that environmental degradation tends to get worse as modern economic growth occurs until average income reaches a certain point (Shafik 1994; Grossman and Krueger 1995).

- However, the explanatory power (autonomous consequence of increased wealth) and general validity (other emissions incl. CO_2 and NH_3) of this hypothesis have been strongly contested.

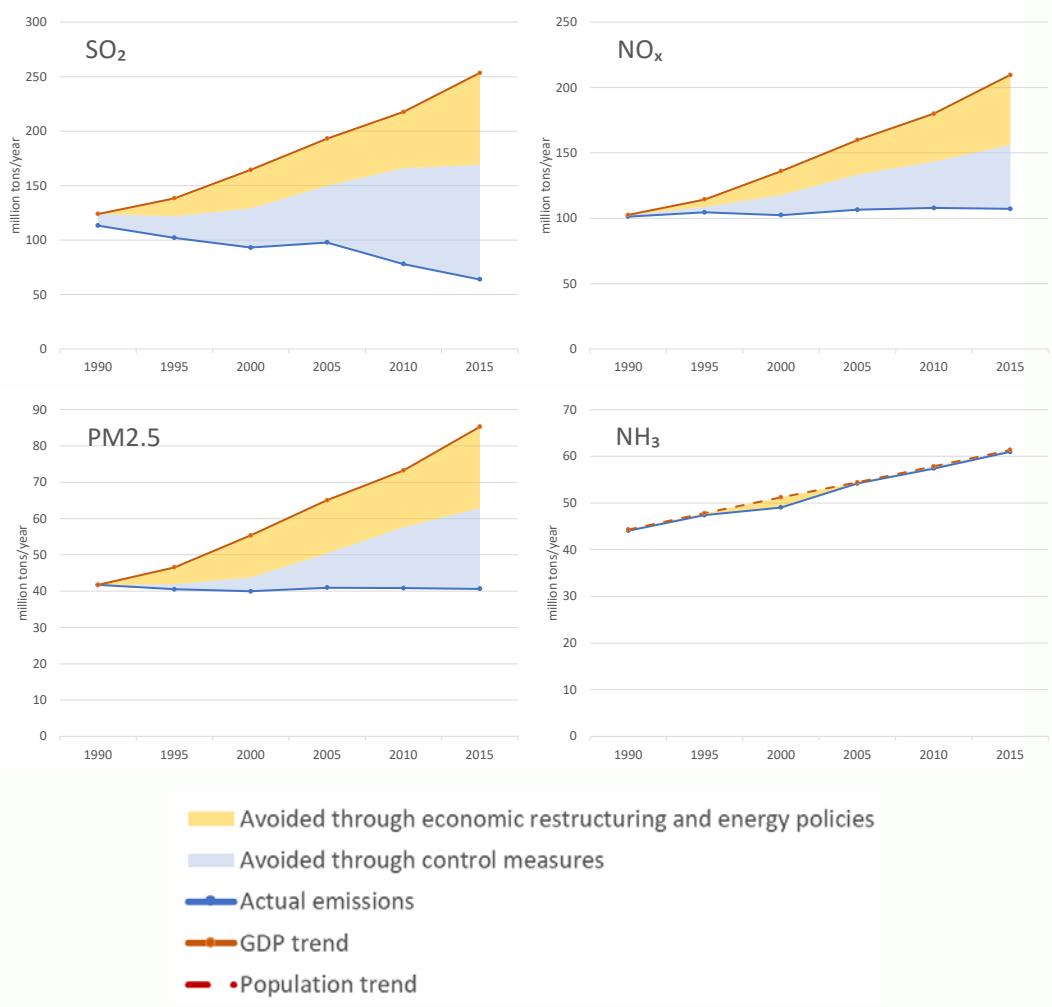
Per-capita emissions and income, 1990 to 2015



Policy interventions were the main reasons for the observed decoupling between GDP and emission trends

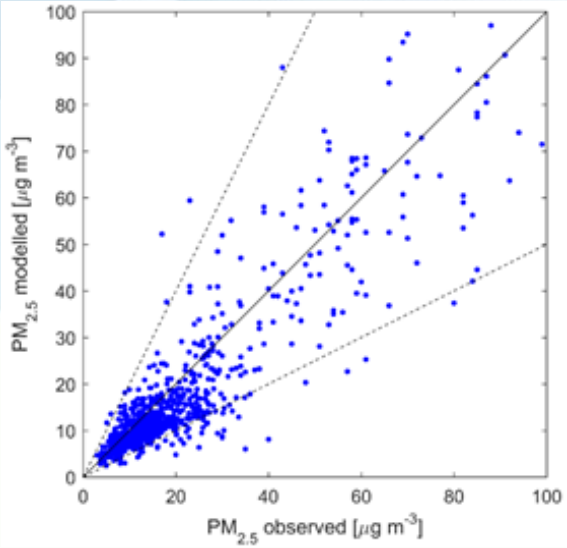
- Decomposition analysis reveals the critical role of policy interventions
- Only half of the decoupling is explained by environmental policies, while the remainder emerged as side-effect of other policy areas
- No decoupling from GDP/population is yet observed for NH_3 emissions

Factors contributing to the decoupling between GDP and emission trends, 1990-2015

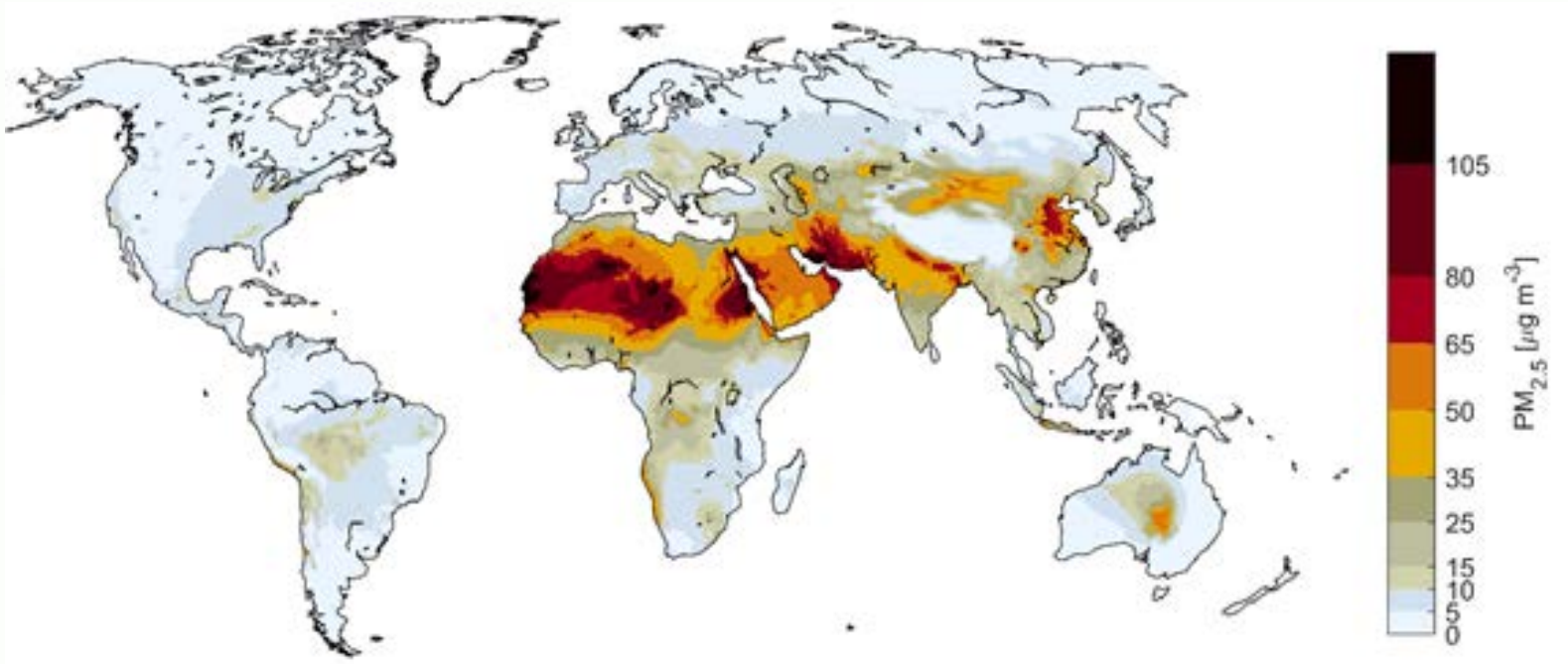


GAINS/EMEP modelling of global PM2.5

- GAINS emission estimates for 180 source regions
- Source-receptor relationships derived from the global EMEP model
- Spatial resolution:
  - 6,000 cities with >100,000 inhabitants
  - 0.125°×0.0625° in Europe
  - 0.1°×0.1° outside of Europe



Computed PM2.5 concentrations in 2015, including natural sources

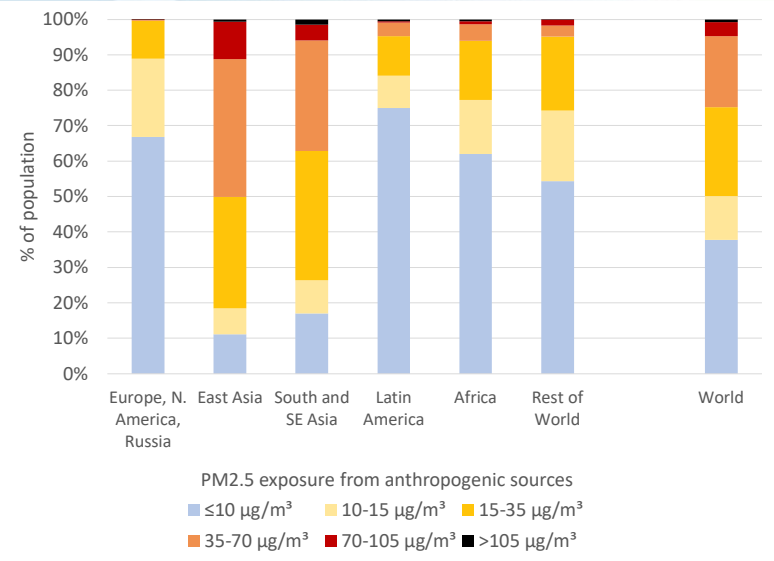


WHO guideline value: 10 µg/m³

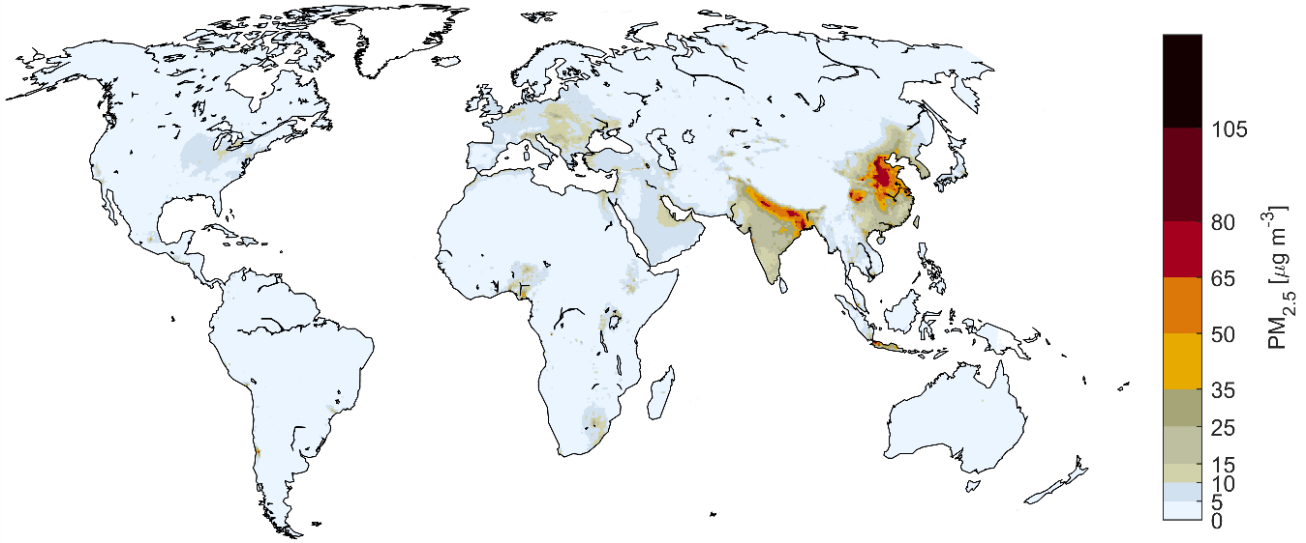
PM2.5 concentrations from anthropogenic sources only

- While the WHO guideline for PM2.5 refers to total PM2.5, there is uncertainty about the relative impacts of different sources/chemical species
- In particular, the role of PM2.5 from natural sources (soil dust, sea salt, biogenic) is currently under review for the WHO guideline revision

Distribution of population exposure to PM2.5 from anthropogenic sources in 2015



Computed PM2.5 concentrations in 2015 from anthropogenic sources only



Outlook to 2040: three policy intervention scenarios

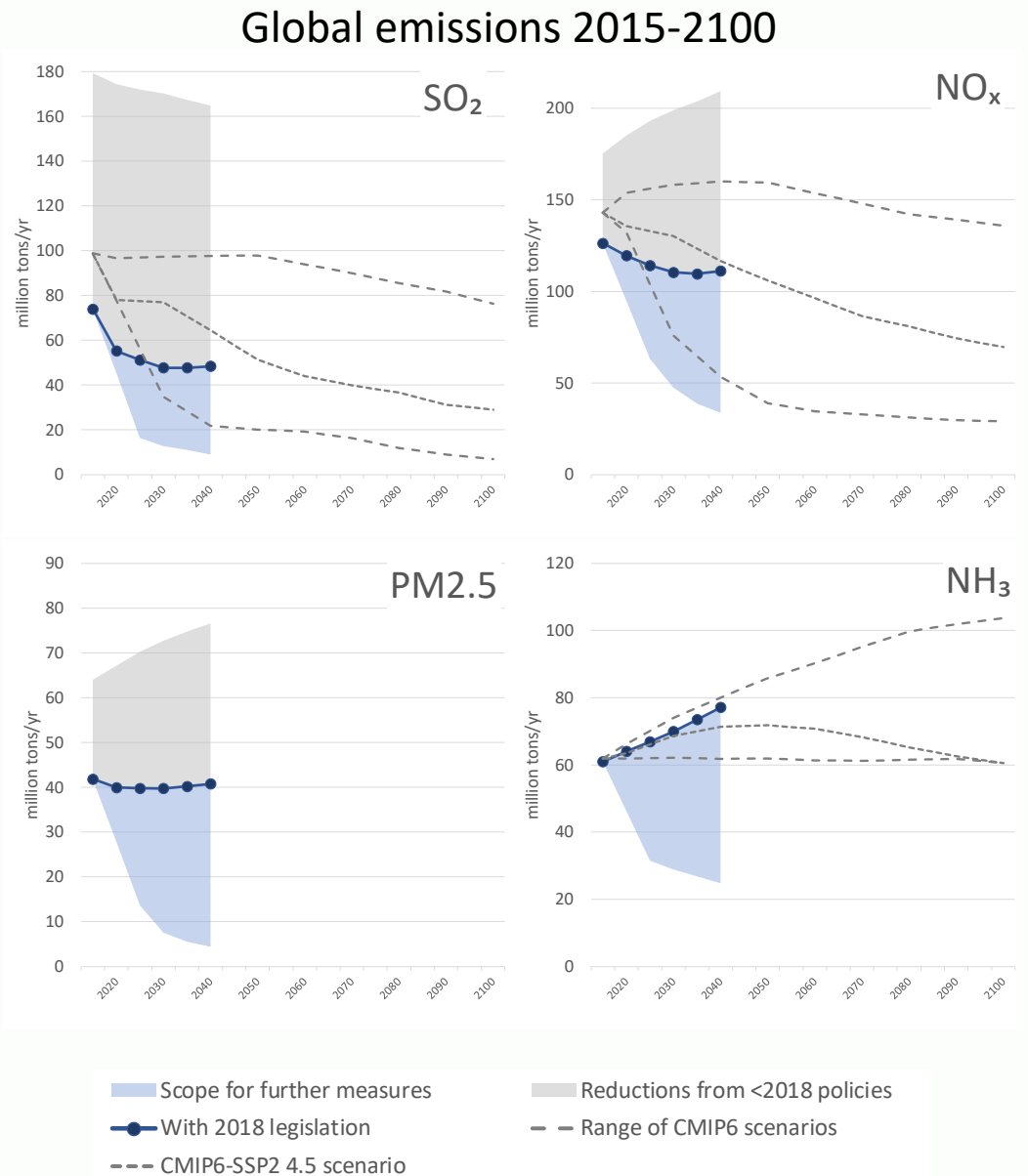
1. **Without air pollution policies** – a hypothetical benchmark

2. **With 2018 legislation**, including
   - Energy policies of 2017 as reflected by the 'New Policies Scenario' of the IEA WEO 2018, incl. NDCs
   - Food and agricultural policies - based on FAO, current consumption trends applied to assumed population and income growth, considering ongoing technological progress, and changes in agricultural practices
   - National air pollution control policies and measures

3. A **Clean Air scenario** with four policy packages:
   - 'Air pollution policies' package: Maximum technically feasible add-on emission controls
   - 'Energy and climate policies' package: 'Sustainable Development' energy scenario of the IEA WEO 2018
   - 'Agricultural policies' package: Low-emissions agricultural practices: enclosed manure treatment at large farms (e.g., anaerobic digestion, composting), residual products replace mineral fertilizers; small farms deliver manure to central processing facilities and/or extend grazing periods; increased nitrogen use efficiency.
   - 'Food policies' package: Lower meat production through modified human diets and reduced food waste, following the 'Planetary Health Diet' of the EAT-Lancet Commission on Food, Planet and Health as quantified by the IIASA/GLOBIOM model for the Food and Land Use Coalition (2019)

Range of future emissions

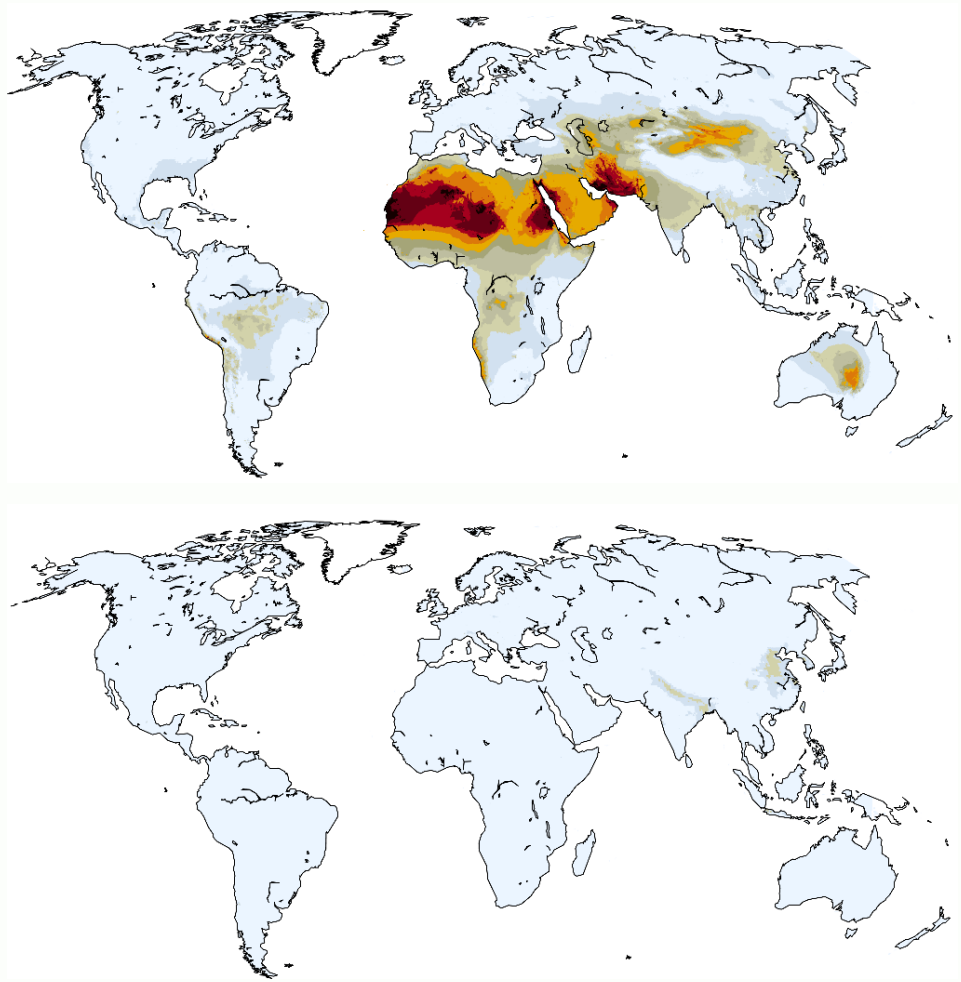
- Without the current air pollution legislation, SO_2, NO_x and PM emissions would be 2-3 times higher.
- At the global scale, implementation and enforcement of the 2018 air legislation will compensate pressure from further economic growth.
  Emissions might rebound after 2030.
- The further emission declines assumed by the climate modelling community would require further policy interventions.
- The full range of policy interventions could reduce emissions by about half in 2040.
- There is no sign for a trend reversal of NH_3 emissions.
  The business-as-usual projection resembles the most pessimistic scenarios of the climate modelling community.



Clean Air scenario 2040: PM2.5 concentrations

- The Clean Air scenario would bring PM2.5 exposure from anthropogenic sources below the current WHO guideline for ~90% of the global population
- Over large areas, PM2.5 concentrations from anthropogenic sources would drop below 5 µg/m³
- Remaining hot spots (China, India) are related to the assumptions on the spatial intensities of population and industrial production – needs further analyses, i.a., of global trade flows
- N.B.: The linear GAINS source-receptor relationships tend to underestimate improvements from the deep emission cuts

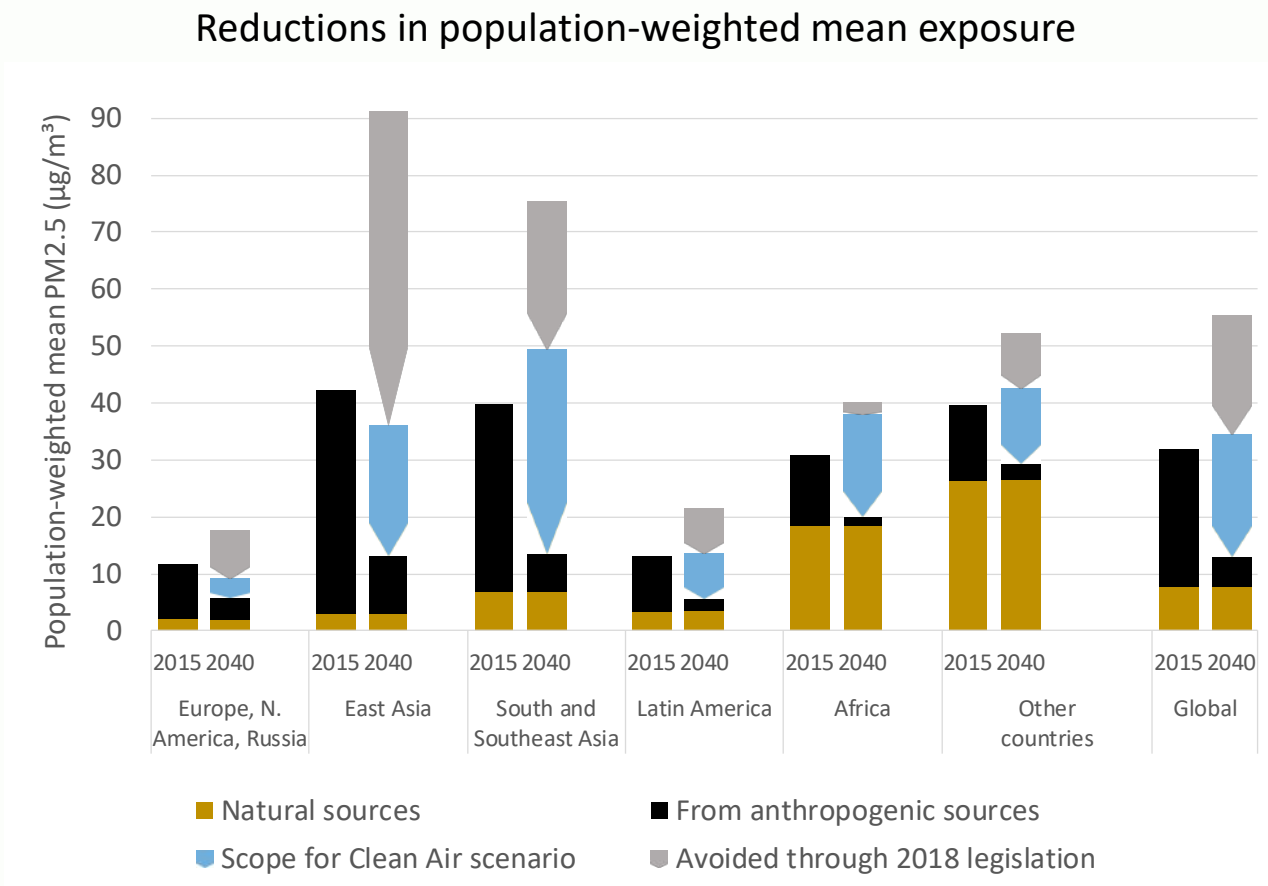
A. Total PM2.5 including natural sources



B. PM2.5 from anthropogenic sources only

Trends and potentials for the policy interventions vary over regions

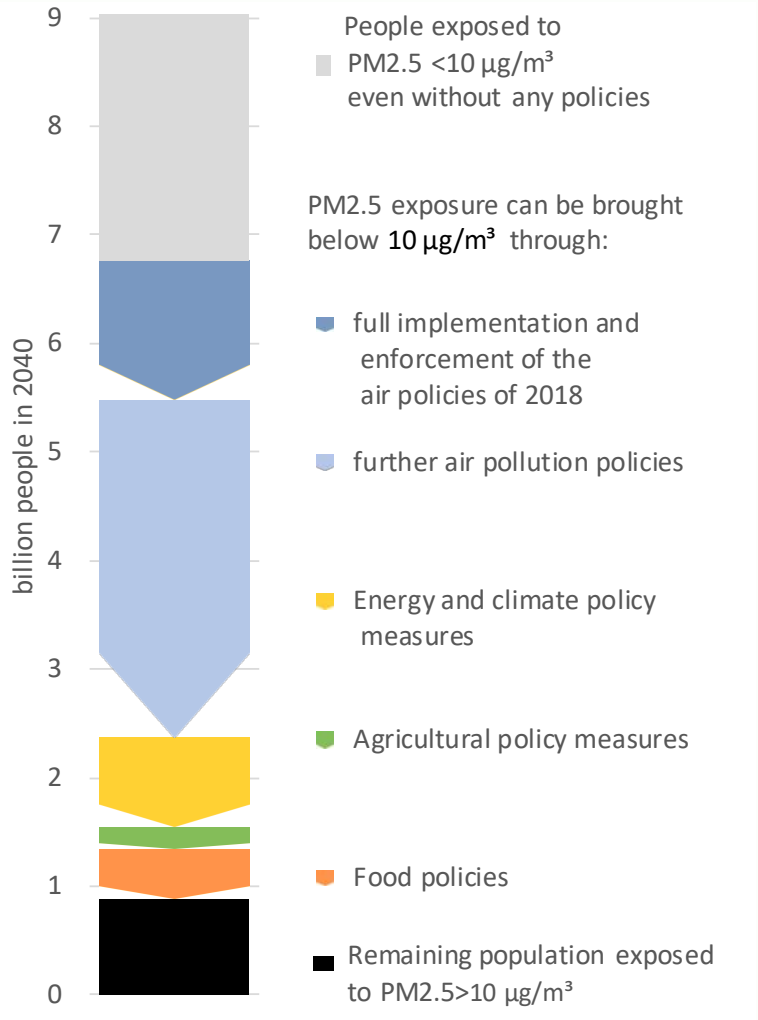
- Enforcement of the 2018 legislation will be essential for stabilizing current pollution levels
- Further policy interventions have largest potentials in developing countries
- The relevance of natural sources varies across regions



Moving towards the WHO guideline requires a mix of policies

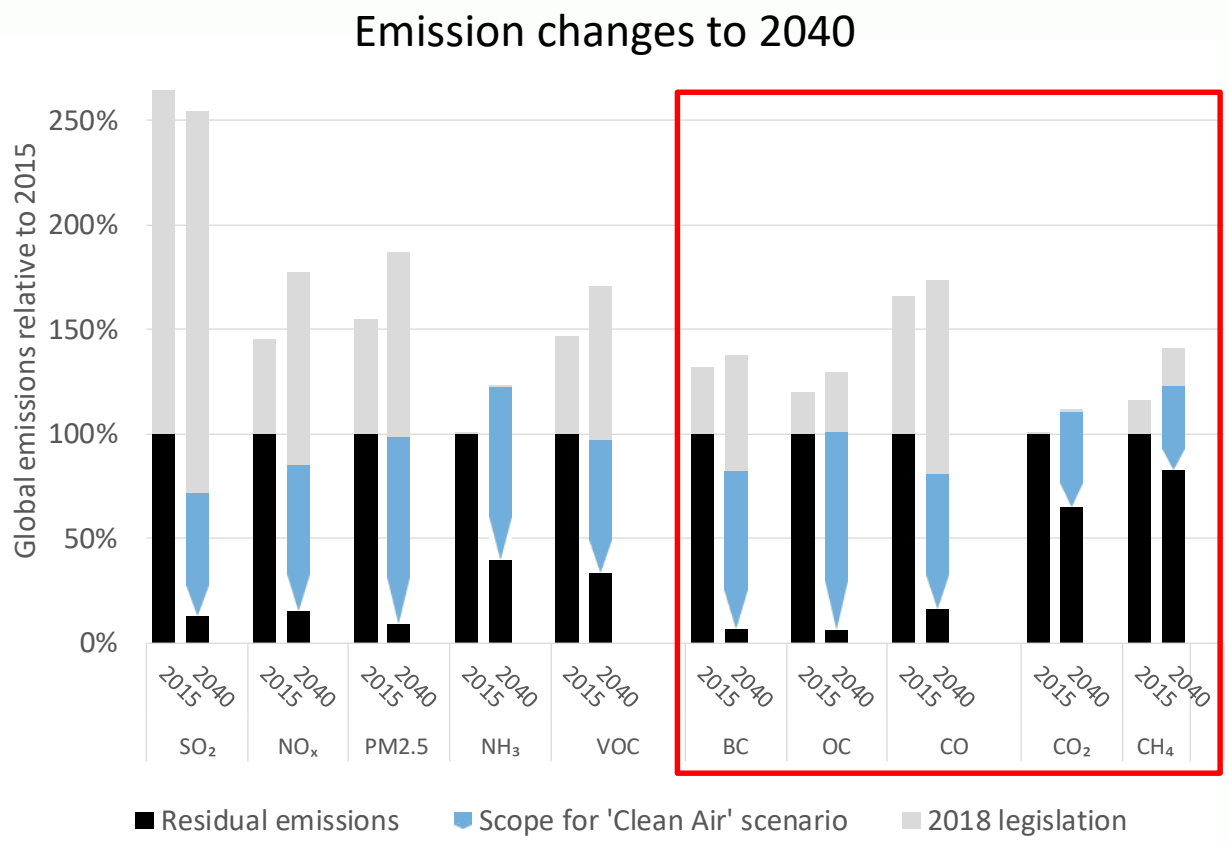
- No single policy field alone can exhaust the full potential for air quality improvements
  - About 2/3 of the potential improvements can be delivered by further air quality policies
  - The remaining 1/3 is connected to other policy fields, including
    - energy and climate policies,
    - food policies,
    - agricultural policies.
- Achieving clean air requires integrated multi-sectoral policy approaches
- **A role for the Global Forum on Air Pollution that has been launched by the Air Convention in Dec 2019!**

Population exposed to PM2.5<10 µg/m³ from anthropogenic sources in 2040



Multi-sectoral solutions to achieve clean air will deliver a wide range of benefits on multiple development priorities

- Direct health benefits on health (SDG 3 – Improve human health and wellbeing), particularly in urban areas (SDG 11 – Sustainable cities and communities)
- The Clean Air scenario cuts global emissions of BC by 90%, of CH_4 by one third, of CO_2 by 40% below the 2018 legislation case in 2040 (SDG13 – Climate action)
- Its measures enhance energy efficiency and access to clean energy (SDG 7 – Affordable and clean energy).
- Improved nitrogen use efficiency contributes to SDG 2 (Zero hunger), SDG 14 (Life under water), SDG 15 (Life on land), SDG 12 (Responsible consumption and production).



Seven key messages (1)

1. Policy interventions were instrumental in decoupling energy-related air pollution from economic growth in the past, and **further interventions will determine future air quality**.

2. At the global scale, even full implementation and enforcement of **current policies are unlikely to reduce present exposure** [and health burden] from air pollution in the next 20 years. Improvements in North America, Europe and East Asia will be compensated by further deterioration in South Asia, Africa and the Middle East.

3. Theoretically, a portfolio of a**mbitious policy interventions could bring ambient PM2.5 concentrations below the WHO air quality guideline** in most parts of the world, except in areas where natural sources (e.g., soil dust) contribute major shares to or even exceed the current guideline value.

Seven key messages (2)

4. Such a portfolio needs to **integrate over multiple policy domains**:

   (i) environmental policies focusing on pollution controls,

   (ii) energy and climate policies,

   (iii) policies to transform the agricultural production system, and

   (iv) policies to modify human food consumption patterns.

   None of these policy areas alone can deliver clean air, and interventions need to be coordinated across sectors.

Seven key messages (3)

5. These policy interventions would require **fundamental transformations** of today's practices in many sectors. They are **visionary** but considered likely to be **technically achievable** in the future. As they exceed current policy ambitions, their implementation would require **strong political will**.

6. Political will could emerge from a **solid understanding** of the full range of **benefits,** including their contributions to the UN Sustainable Development Goals.

7. Lowering **emissions from agricultural activities and meat production** will be **critical for achieving clean air** worldwide.

Conclusions

- ~90% of world population is exposed to PM2.5 above the WHO guideline; this is linked to millions of premature deaths annually.
- As current PM2.5 levels exceed the guideline by up to a factor of 15, reaching the guideline seems illusionary.
- GAINS analysis: A mix of policy interventions could bring exposure from anthropogenic sources below the current WHO guideline for 90% of the world population. 5 mg/m3 seems achievable throughout most areas in the world
- While there is a clear role for further air pollution policies, **the portfolio needs to involve energy, climate, agricultural and food policies** as well.
- Many of the required policies also serve global and long-term development goals; their near-term co-benefits on health could provide motivation to trigger the transitions.