Ozone and health

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Workshop on Air Quality Policy Implementation Related to Ozone
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The WHO European Region

53 Member States,
900 000 000 population

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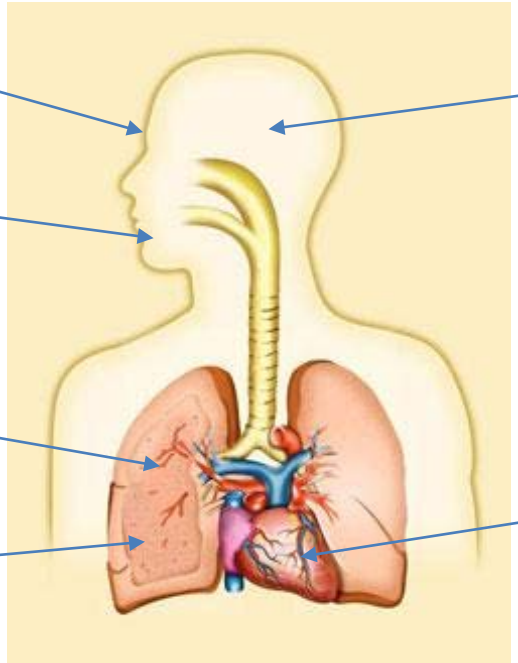
Multiple effects of exposure to ozone

Burning eyes & throat; mucous irritation

Shortness of breath, wheezing, coughing

Pulmonary inflammation

Asthma attacks, chest pain, increased risk of respiratory diseases



Headache

Increased risk of heart attacks

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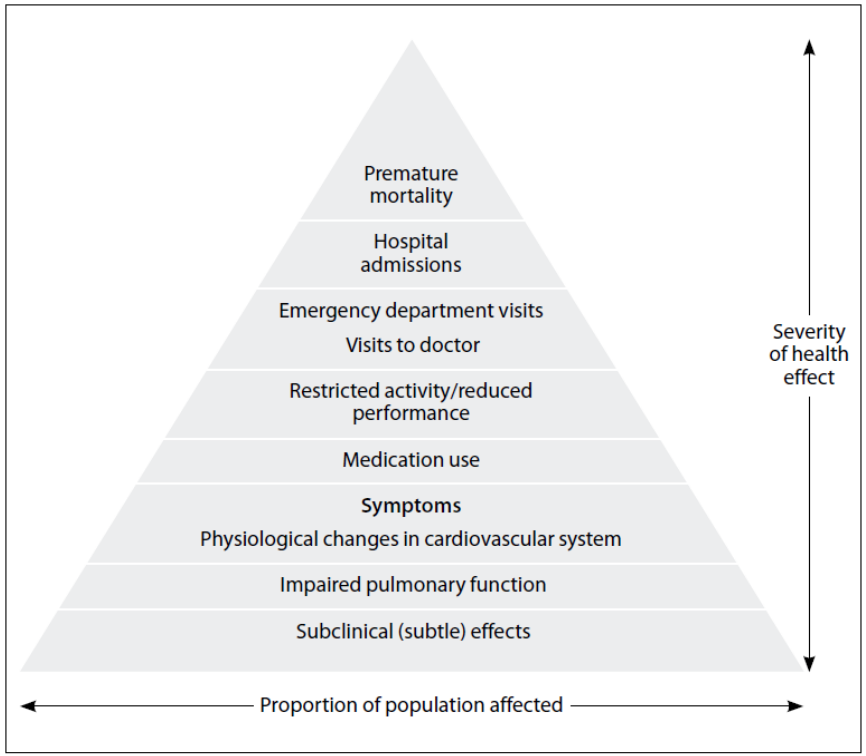
Source of the image: https://www.epa.gov/ground-level-ozone-pollution/health-effects-ozone-pollution

Pyramid of health effects



People at higher risk

- people with asthma
- children
- older adults
- people active outdoors – vigorously exercising, outdoor workers
- people with certain genetic characteristics
- malnutrition

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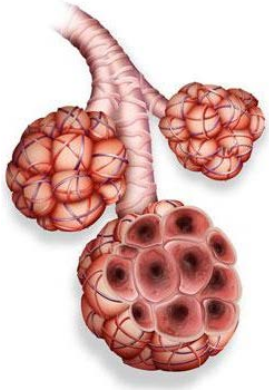
WHO, 2005

Mechanisms of ozone-dependent injury

- Complex events triggered by exposure to ozone
  - direct oxidation of cellular constituents
  - induction of respiratory and systemic inflammation
  - neural reflexes
- Adaptive and protective mechanisms
- Impacts on immune system
- Factors affecting susceptibility and tolerance to ozone

Central role of inflammation in ozone-dependent injury

- Inflammation of the respiratory tract detected at ambient ozone levels
- Inflammatory reaction with cellular influx and release of mediators and cytokines
- Dose-dependent association between ozone and pulmonary inflammation
- Indication of a systemic inflammatory response
- Impairment of pulmonary defence: mucociliary clearance, macrophage activity and effects on circulating lymphocytes



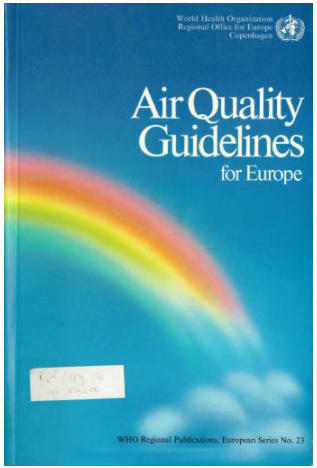
Neural reflexes in ozone-dependent injury

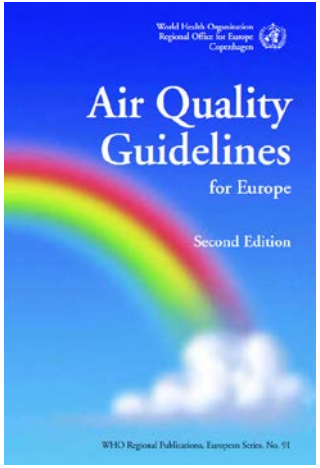
- Stimulation of airway sensory nerves – effect of mucus secretion, bronchoconstriction and permeability of lung microcirculation
- Contribution to the inflammatory process
- Enhancing or protective effect of neuropeptides on lung inflammation

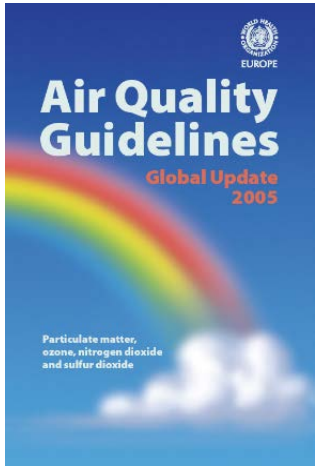
Mechanisms of ozone-dependent injury (2)

- Partial adaptation to ozone after repeated exposures due to upregulated defence mechanisms
- Still, persistent pulmonary inflammation occurring, mainly in the terminal bronchiolar segments
- Structural lung alterations - bronchiolar narrowing, alveolar fibrosis, mucus hyperplasia, after longer exposure to ozone
- Pre-existing pulmonary disease, age and genetic factors influence susceptibility to ozone injury

Ozone in WHO air quality guidelines (WHO AQGs)







Update of WHO Global Air Quality Guidelines

Ongoing update

1987 **2000** **2006** **since 2016 …**

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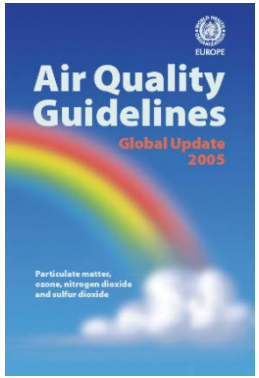
Acute and chronic effects of ozone

Acute responses

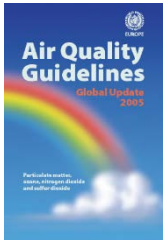
- pulmonary system effects
- cardiovascular system effects
- time series morbidity and mortality effects

Chronic effects

- reduced lung function
- development of atherosclerosis
- development of asthma
- reduction in life expectancy

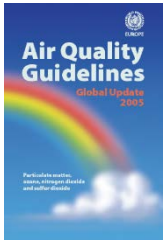


Acute responses to ozone – pulmonary system



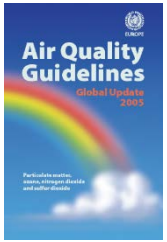
- Solid evidence of impaired pulmonary function
- Transient obstructive pulmonary alterations for exposures to common ozone concentrations
- Higher susceptibility of people with asthma and allergic rhinitis to changes in respiratory function
- Changes in pulmonary function and depletion of airway antioxidant defence immediately after ozone exposure
- Enhanced airway responsiveness in both healthy individuals and asthmatics
- Transient functional effects reported in field studies (such as summer camps), at ozone levels considerably lower than in controlled exposures

Acute responses to ozone – cardiovascular system, morbidity and mortality



- Less and inconclusive evidence on cardiovascular system effects; methodological challenges to distinguish effects due to ozone from those due to PM
- Solid evidence on increased morbidity, mainly for respiratory conditions
- Significant association between ozone and respiratory symptoms in asthmatic children
- Robust associations between ozone and the numbers of hospital admissions for respiratory conditions (after controlling for several factors)
- Less evidence on the links between ambient ozone and cardiovascular morbidity
- Significant associations with respiratory mortality and (to a lesser extent) cardiovascular
- Mortality effects detected mostly in the elderly
- Seasonal variation in the magnitude of the mortality risk (higher in warmer weather)

Chronic effects of ozone

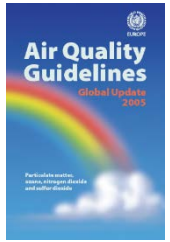


- Human and experimental data indicate that chronic exposure to ozone induces significant changes in airways at the terminal bronchioli (reversibility?)
- Epidemiological evidence of chronic effects less conclusive, due to major methodological challenges
- Epidemiological studies with the most efficient approaches provide evidence for chronic effects of ozone on small airway function and possibly on asthma
- Non-conclusive evidence on cardiovascular effects (systemic inflammation and atherosclerosis)
- The evidence on long-term exposure to ozone and chronic effects not sufficient to recommend an annual guideline value

Guideline value for ozone

	Daily maximum 8-hour mean	Effects at the selected ozone level
WHO air quality guideline	100 µg/m^3	This concentration will provide adequate protection of public health, though some health effects may occur below this level. ***Rationale*** • Estimated 1–2% increase in daily mortality [a] (based on findings of daily time series studies) • Extrapolation from chamber and field studies based on the likelihood that real-life exposure tends to be repetitive and chamber studies do not study highly sensitive or clinically compromised people or children. • Likelihood that ambient ozone is a marker for related oxidants.

[a] Deaths attributable to ozone concentrations above an estimated baseline of 70 µg/m^3 (based on 0.3–0.5% increase in daily mortality for 10 µg/m^3 8-hour ozone).



WHO, AQG 2005

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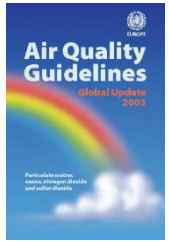
Interim targets for ozone



	Daily maximum 8-hour mean	Effects at the selected ozone level
High level	240 µg/m^3	Significant health effects; substantial proportion of vulnerable population affected.
WHO interim target 1 (IT-1)	160 µg/m^3	Important health effects; an intermediate target for populations with ozone concentrations above this level. Does not provide adequate protection of public health. ***Rationale*** • Lower level of 6.6-hour chamber exposures of healthy exercising young adults, which show physiological and inflammatory lung effects. • Ambient level at various summer camp studies showing effects on health of children. • Estimated 3–5% increase in daily mortality [a] (based on findings of daily time series studies)

WHO, AQG 2005

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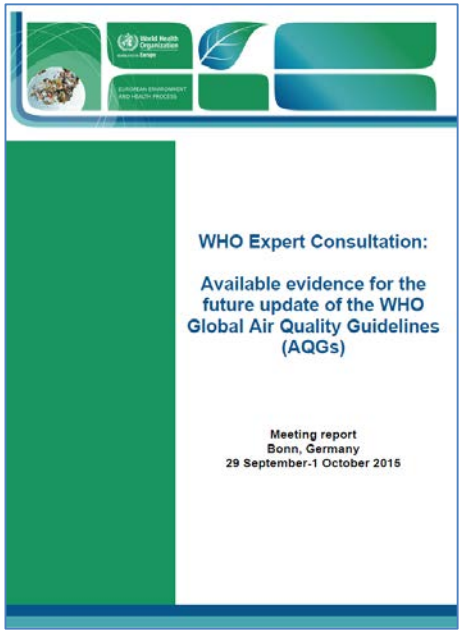
REVIHAAP study – new evidence on ozone

- Evidence for effects of long-term exposure on respiratory and cardiorespiratory (less conclusive) mortality
- Some evidence for effects on mortality in people with predisposing conditions (COPD, diabetes, heart failure and myocardial infarction)
- New evidence on adverse effects on asthma incidence, asthma severity, hospital care for asthma, lung function growth
- Reinforced evidence on effects of short-term exposure on all-cause, cardiovascular and respiratory mortality, and respiratory and cardiovascular hospital admissions
- New experimental evidence of chronic injury and long-term structural changes in the airways due to prolonged exposure to ozone and to ozone and allergens combined
- New epidemiological and experimental data suggesting an effect of ozone on cognitive development and reproductive health, including preterm birth

Expert consultation on the evidence for the update of the WHO Global AQG

A general agreement with the REVIHAAP project conclusions on the classical pollutants, which stated that there is a need to revisit the current guidelines for PM, O_3, NO_2, and SO_2 as the evidence base for the association between short- and long-term exposure to these pollutants and health effects has become much larger and broader since 2006.



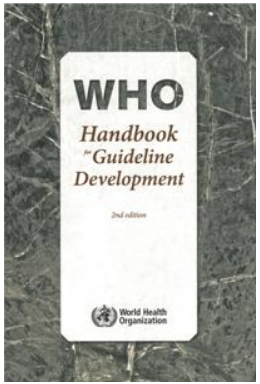
Expert consultation – short term effects

- New mixed evidence of effects at levels below 100 µg/m³ for an average 8-hour mean exposure
- Consideration of additional short-term averaging times
- Consideration of multipollutant models, due to the negative correlation among ozone and other pollutants, which might affect the CRF and threshold determination
- The use of the SOMO35 (sum of mean ozone values over 35 ppb) indicator in the context of addressing management issues rather than in the development of the guidelines

Expert consultation – long term effects

- Support to the REVIHAAP conclusions – to consider the new evidence of adverse health effects due to long-term exposure in the revision of the guidelines
- Consideration the US EPA ISA for Ozone and Related Photochemical Oxidants on:
  - *likely to be a causal relationship between long-term exposure to O3 and respiratory effects*
  - *the evidence was suggestive of a causal relationship for long-term exposure to O3 and cardiovascular effects, reproductive and developmental effects, cancer, and total mortality*
- Strong support to review the evidence to consider the development of a numerical guideline for long-term exposure to ozone
  - potential major policy implications, including the need to address global emissions of ozone precursors, and impacts on other areas such as climate change mitigation and ecosystems
  - need to addressing confounding due to multipollutant exposures, considerations on seasonality, and effects due to repeated peaks of exposure versus chronic exposure

Update WHO Global Air Quality Guidelines (ongoing)



Systematic reviews of evidence

- long- term PM2.5 and PM10 and all-cause and cause-specific mortality (respiratory, cardiovascular and lung cancer)
- long-term NO_2 and O_3 and all-cause and respiratory mortality
- short-term CO and emergency department visits/hospital admissions (ED/HA) due to ischemic heart disease
- short-term PM2.5 and PM10, NO_2 and O_3, and all-cause and cause-specific (PM only) mortality
- short-term SO2, O_3, NO_2 and ED/HA due to asthma

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Abstract

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A cross-disciplinary evaluati
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Review article

Ambient ozone exposure and mental health: A systematic review of epidemiological studies

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ABSTRACT

Background: An increasing number of studies have suggested adverse effects of air pollution on mental health. Given the potentially negative impacts of ozone exposure on the immune and nervous system driven from animal experiments, ozone might also affect mental health. However, no systematic synthesis of the relevant literature has been conducted yet. This paper reviews the studies that assessed the link between ozone exposure and mental health thus far.

Methods: We followed the Preferred Reporting Items for Systematic Review and Meta-analysis (PRISMA). PubMed, Web of Science, and EMBASE were systematically searched for epidemiological studies on ambient ozone exposure and mental or behavioral disorders according to the International Classification of Disease. The period was from January 1st, 1960 to December 14st, 2017. We evaluated the risk of bias by the Office of Health Assessment and Translation (OHAT) Approach and Navigation Guide for each included study.

Results: The keyword search yielded 567 results. 31 papers met the selection criteria and were included in the review. We found only inconclusive evidence that ozone affects autism spectrum disorders, impairment of cognitive functions and dementia, depression, and suicide. The large heterogeneity of study designs, outcome definitions and study quality in general prevented us from conducting meta-analyses.

Conclusions: Current evidence for an association between ambient ozone exposure and mental health outcomes is inconclusive and further high quality studies are needed to assess any potential links given the strong biologic plausibility.

Thank you for your attention

http://www.euro.who.int/en/health-topics/environment-and-health

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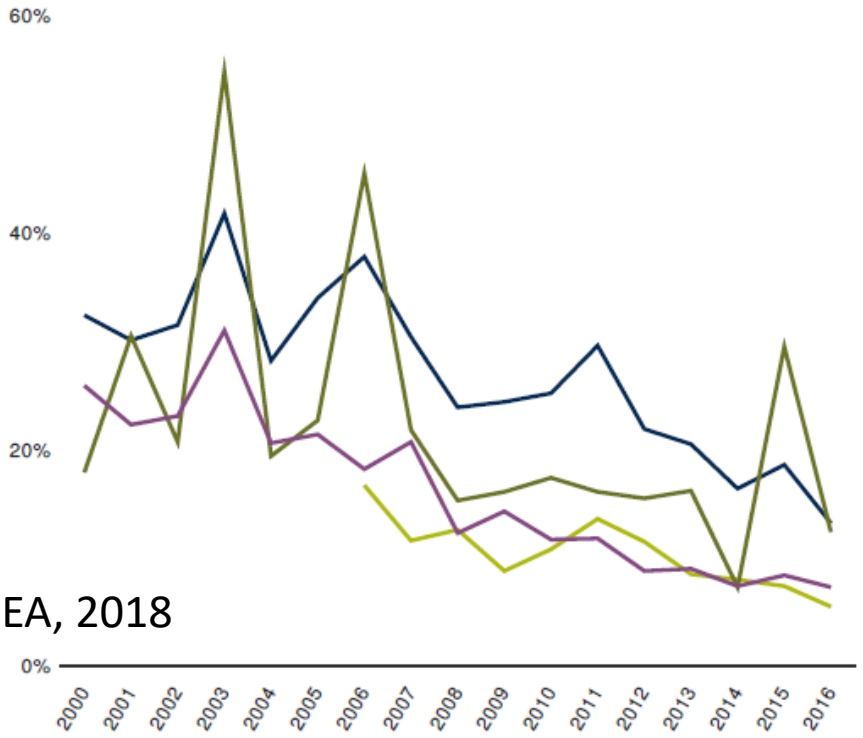
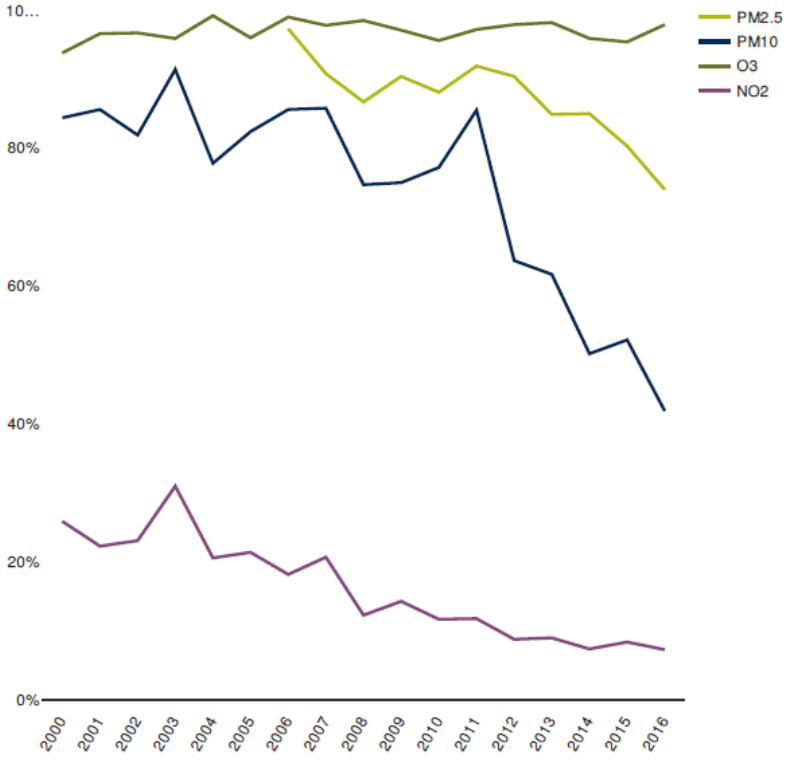
Urban population in EU-28 exposed to air pollutant concentrations

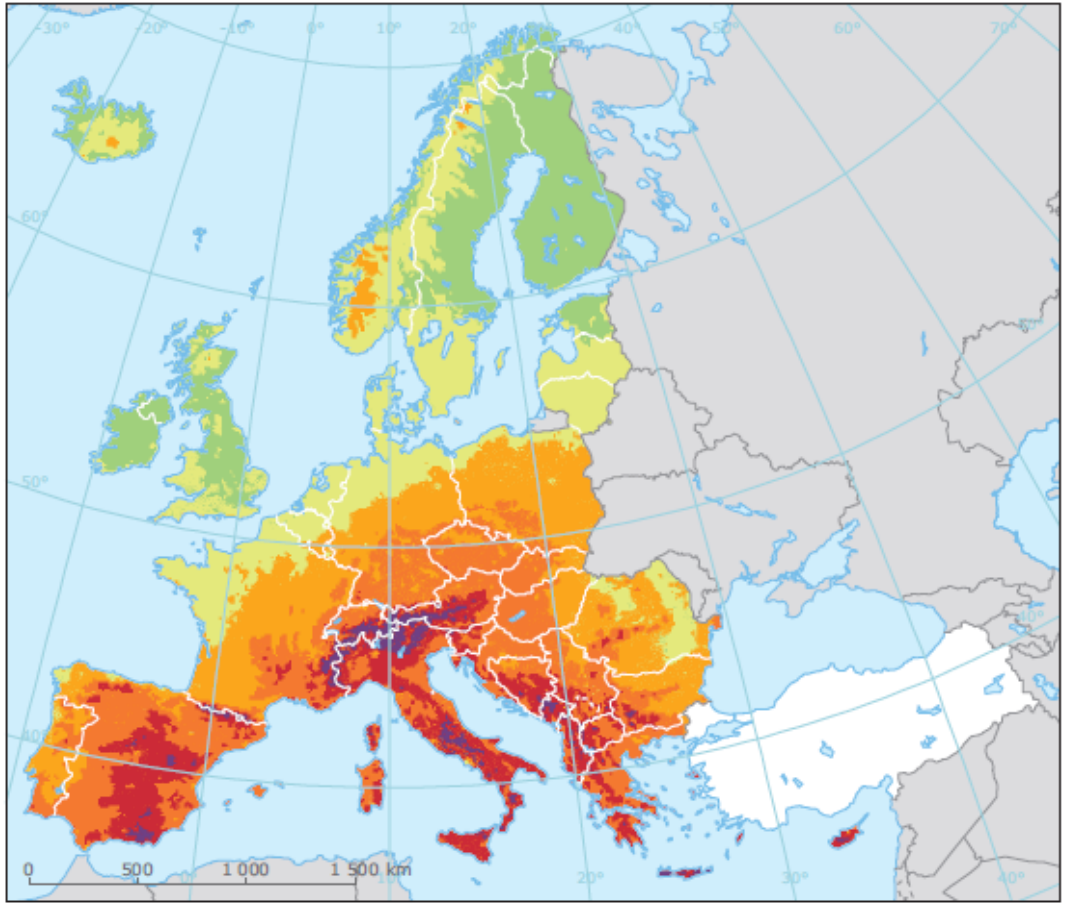
selected EU limit and target values



EEA, 2018

WHO air quality guidelines



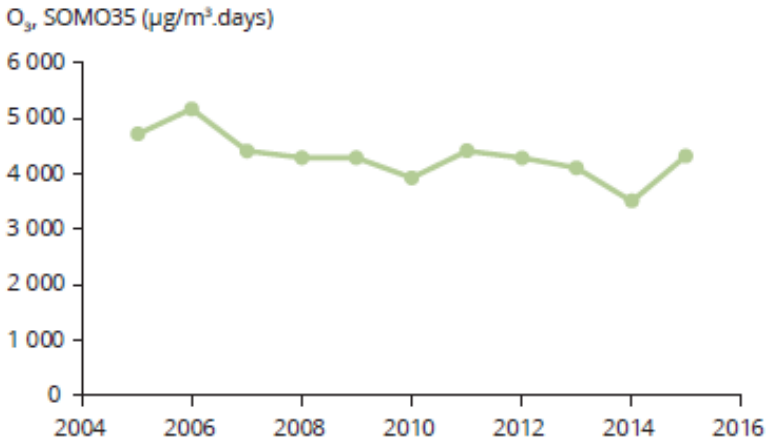


Ozone indicator, SOMO35, in 2015

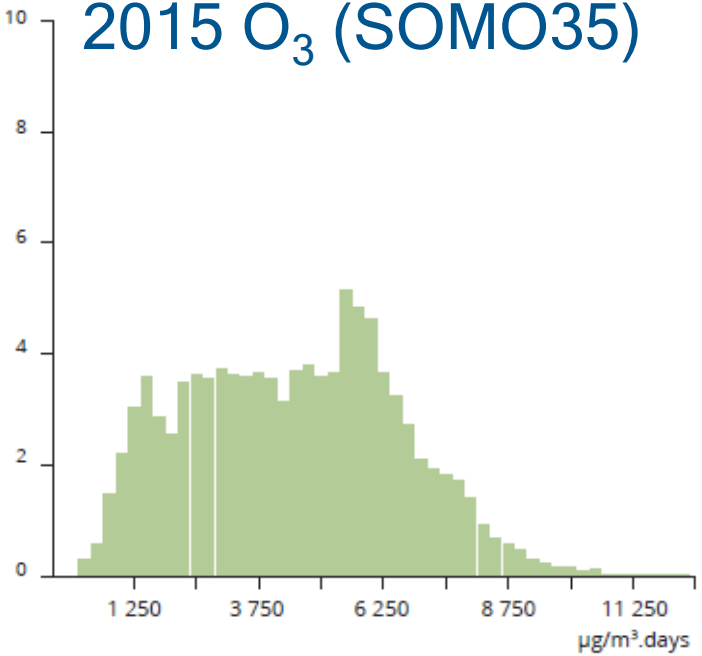
Interpolated map

EEA, 2018

Changes in total European population exposure Ozone (SOMO35)



Frequency distribution of the total population exposure in 2015 O_3 (SOMO35)



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