ITINERIS

Training event “Climate change and air quality: challenges and objectives for the atmospheric research.”

IR0000032 – ITINERIS, Italian Integrated Environmental Research Infrastructures System
(D.D. n. 130/2022 - CUP B53C22002150006) Funded by EU - Next Generation EU PNRR-Mission 4 “Education and Research” - Component 2: “From research to business” - Investment 3.1: “Fund for the realisation of an integrated system of research and innovation infrastructures”

Finanziato dall'Unione europea NextGenerationEU
Ministero dell'Università e della Ricerca
Italiadomani

URBAN AND REGIONAL AIR QUALITY

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Institute of Environmental Assessment and Water Research

Environmental Geochemistry & Atmospheric Research

Department of Geosciences

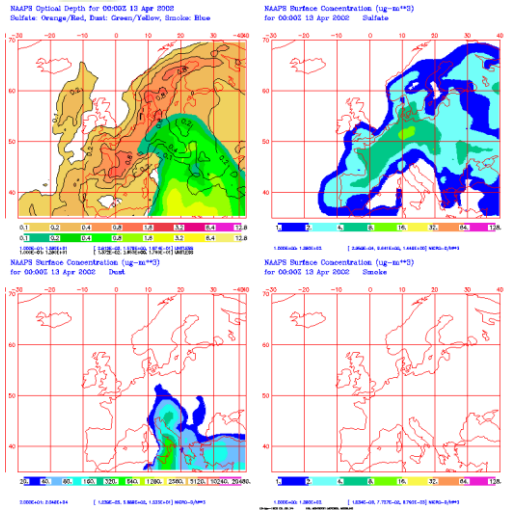
Outline

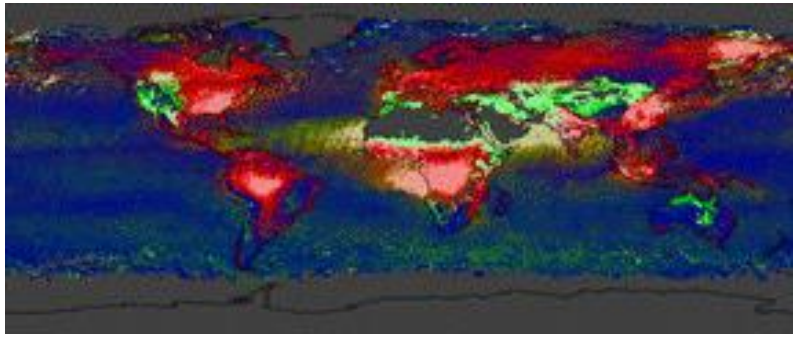
- ATMOSPHERE & POLLUTION
- CRITICAL AIR QUALITY PARAMTERS IN EUROPE
  - NO_2
  - PM
  - BaP
  - O_3

Atmospheric pollution

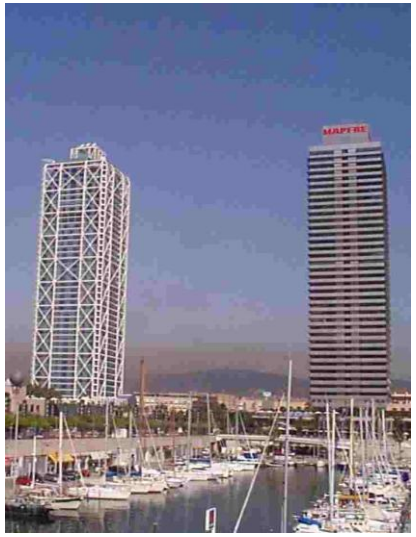
THE SCALES OF ATMOSPHERIC POLLUTION

Planetary-Global: Global warming & Climate change
Stratospheric ozone depletion





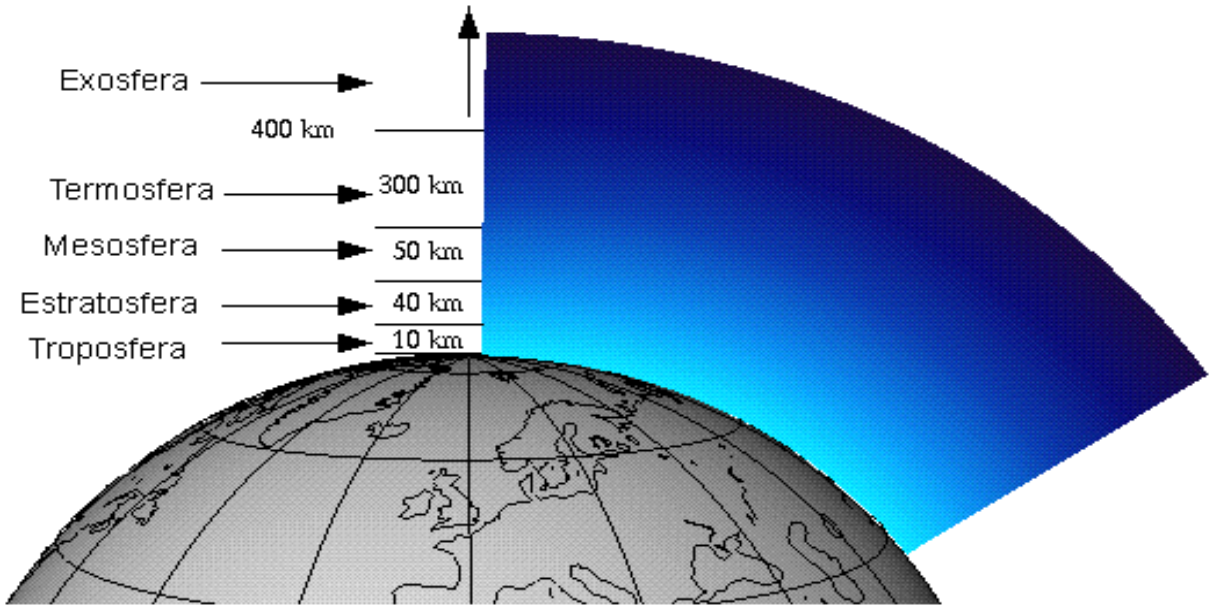
Meso-scale: Acidification, tropospheric ozone, desert dust

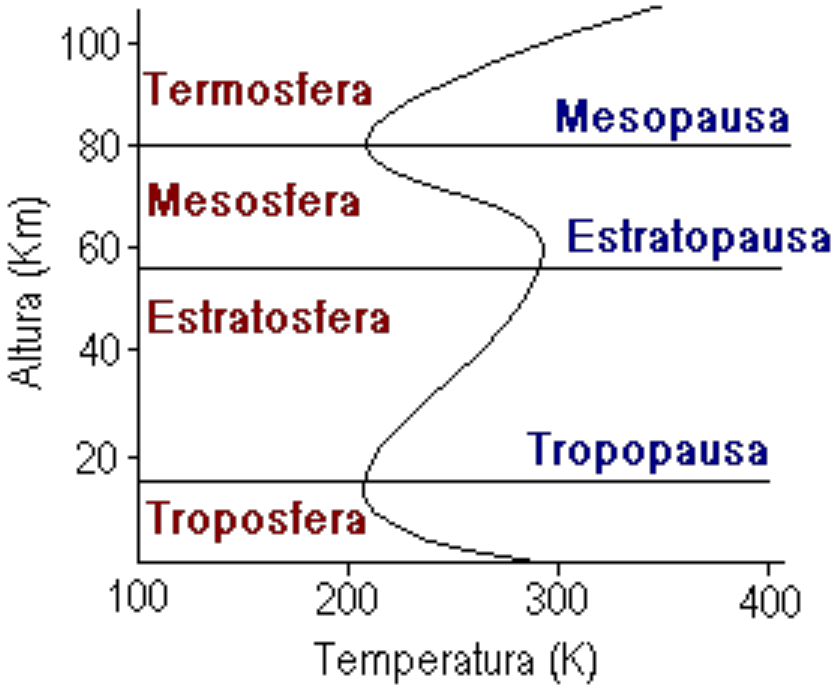


Micro-scale: Air quality, road traffic impact, industry, domèstic-residential, agriculture....

Indoor air quality: Air quality in homes, schools, offices, commuting,....

Atmospheric pollution





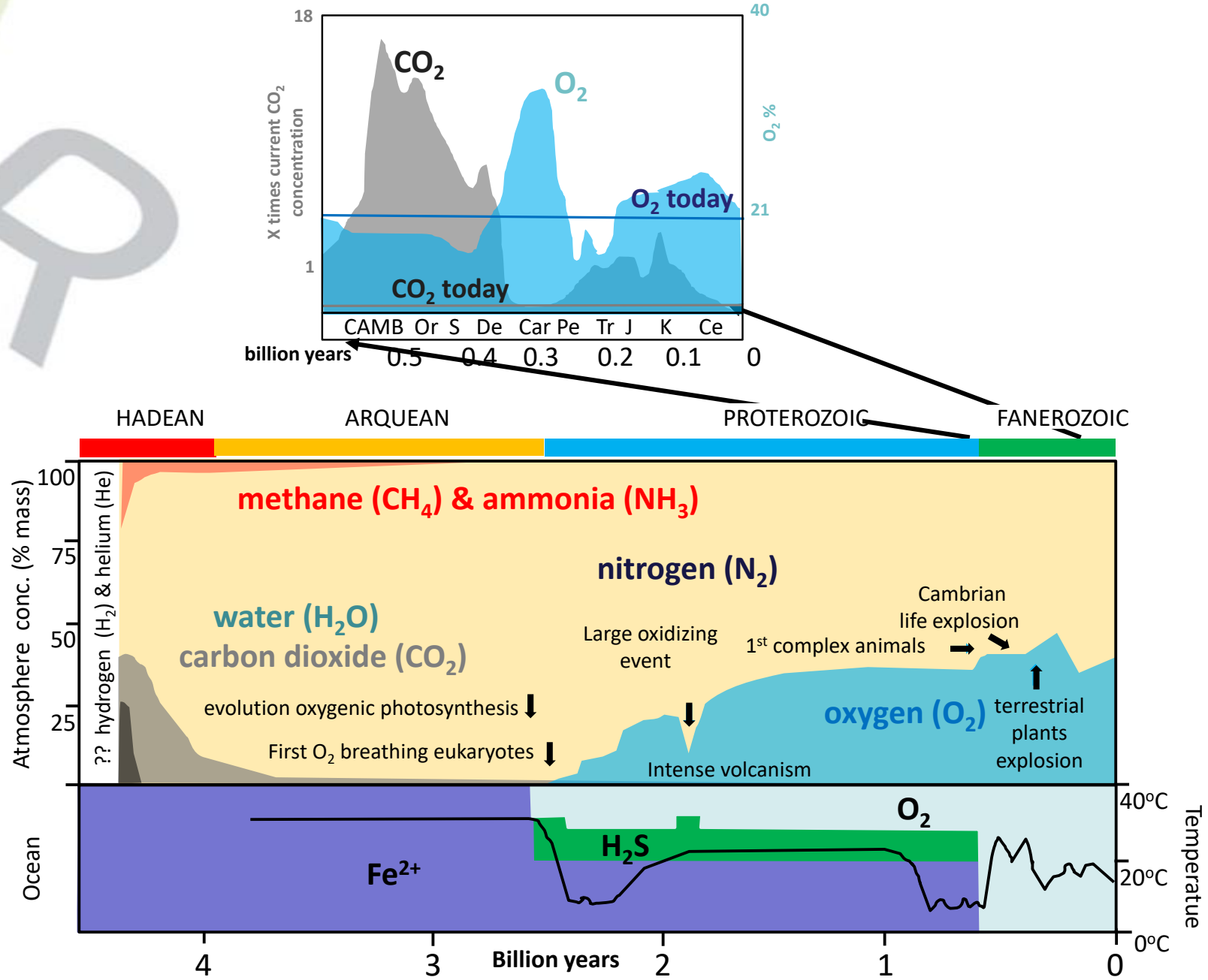
Blue colour due to light dispersion by air molecules

Troposphere: meteorological processes take place, 8km (poles) and 18km (equator)
70% atmosphere weight, T gradient of 6,5°C/km

Residence time (t)

- Permanent gases, con t>1000 years: **N_2 (78%v), O_2 (21%v) and** noble gases
- Variable gaseous species, 100<t>1 years: **CO_2 (425 ppmv),** CH_4, H_2, N_2O, O_3
- Highly Variable gaseous species, t<1 year $H_2O_{(v)}$: **CO (<1ppmv),** NO_2, NH_3, **SO_2 (ppbv),** H_2S,…..

Atmospheric pollution



ATMOSPHERIC DIFUSION OR DISPERSION

Emission characteristics

Pollutant load

T and V of emission

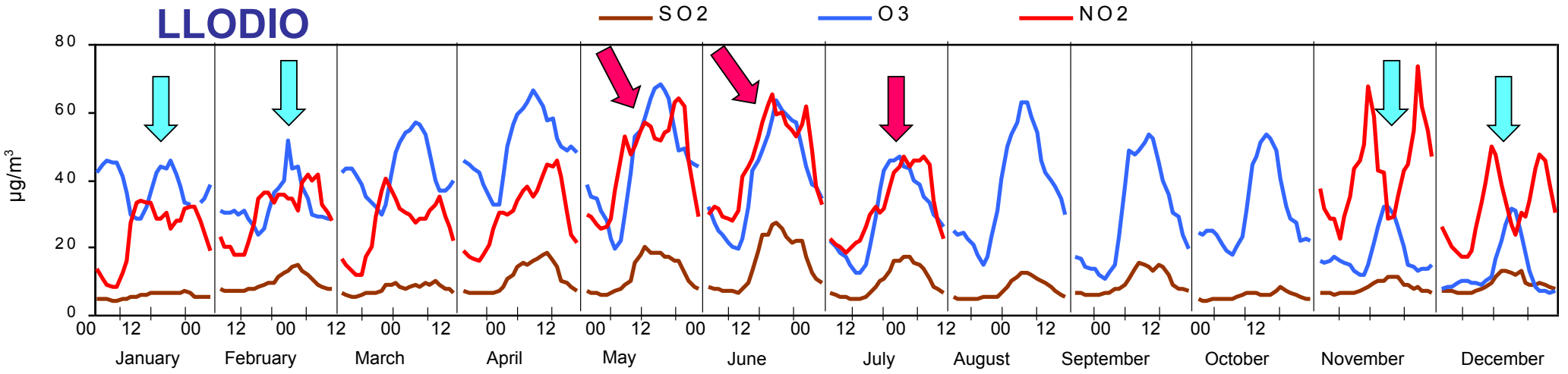
High of emission

Meteorological features

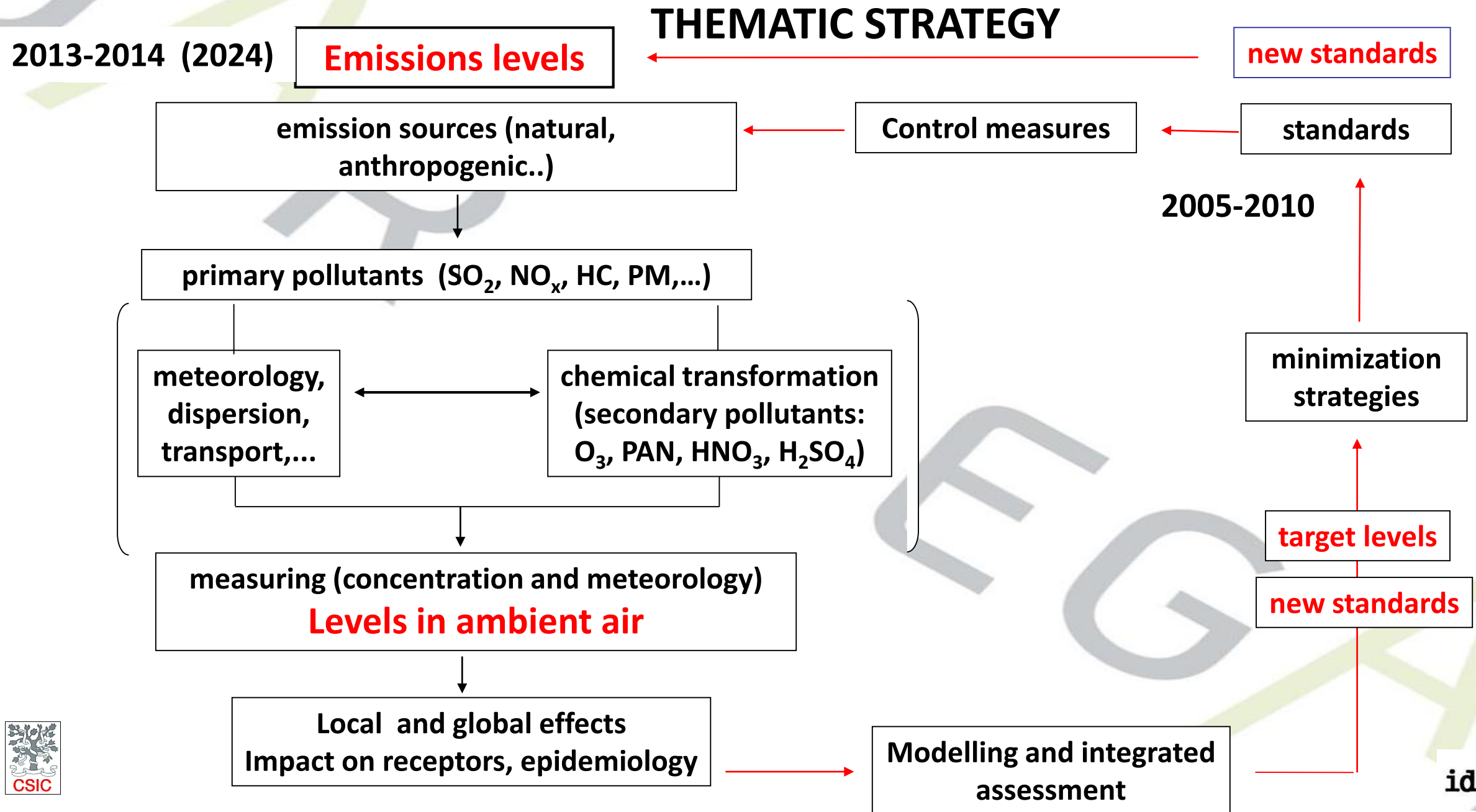
Atmospheric stratification, W-V, W-D, convection

Topographic and local effects

Marine and slope breeze, topographic obstacles



Atmospheric pollution



Emission

ENVIRONMENTAL STANDARDS FOR AIR QUALITY

DIRECTIVES

1996/61/EC. 2008/1/EC. 2010/75/EC
2002/51/EC, 2006/120/EC
1998/69/EC, 2002/80/EC, 2007/715/EC
2001/80/CE
2016/2284/EU
EU 2015/2193

- IPPC Integrated Prevention and Pollution Control, substituted by the Industrial Emissions Directive (IED)
- EURO standards for vehicles

- Large Combustion Plants
- National Emission Ceilings
- Medium scale combustion plants

MOTHER DIRECTIVE

1996/62/CE

NEW EU AIR QUALITY DIRECTIVE 2024/2881 WITH LIMIT VALUES FOR 2030, EVEN WHEN WHO (REVIHAAP+HRAPIE PROJECTS) IN 2013 RECOMMENDED CHANGING LIMIT & TARGET VALUES

Directive 1999/30/EC	• SO_2, NO_2, NOx, PM_{10}, Pb ($PM_{2.5}$??)
Directive 2000/69/EC	• benzene, CO
Directive 2002/03/EC	• O_3
Directive 2004/107/EC	• PAH, Cd, As, Ni, Hg

(PM2.5) → Directive Clean Air for Europe and Air Quality. 2008/50/EC & 2004/107/EC

Deadlines: 2005-2010, 2015, 2024, 2030

NEW DIRECTIVE 2024/2881

2024/2881

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Atmospheric pollution

	2008/50/EC & 2004/107/EC RD 102/2011*	OMS (2005) Guidelines**		OMS (2021) Guidelines	New Directive 2024/2881
Hourly	350* µg/m³ SO_2	500 µg/m³ SO_2	*24 h/yr		350 µg/m³ (1 d/yr)
Daily	125* µg/m³ SO_2	20 µg/m³ SO_2	*3 d/yr	40 µg/m³	50 µg/m³ (18 d/yr)
Hourly	200 µg/m³ NO_2	CE-OMS coincide	18 h/yr		200 µg/m³ (0 h/yr)
Daily					50 µg/m³ NO_2
Annual	40 µg/m³ NO_2	CE-OMS coincide	not exceed.	10 µg/m³	20 µg/m³ ALV, 50 µg/m³ DLV
Annual	5 µg/m³ C_6H_6	CE-OMS coincide	not exceed.		3.4 µg/m³
MD8h	10 mg/m³ CO	CE-OMS coincide	not exceed.		10 mg/m³ (MD8h) 4 mg/m³ DLV
Annual	500 ng/m³ Pb	CE-OMS coincide	not exceed.		No changes
Annual	40 µg/m³ PM10	20 µg/m³ PM10	not exceed.	15 µg/m³	20 µg/m³
Annual	25 µg/m³ PM2.5	10 µg/m³ PM2.5	not exceed.	5 µg/m³	10 µg/m³
Daily	50* µg/m³ PM10	50** µg/m³ PM10	** 3 o *35 d/yr	45 µg/m³	45 µg/m³ (18 d/yr)
Daily				15 µg/m³ PM2.5 3 d/yr	25 µg/m³ (18 d/yr)
MD8h	120 µg/m³ O_3	100 µg/m³ O_3	25 d/yr	100 µg/m³	120 µg/m³ (3 d/yr)
Mean 3 yr Annual	1 ng/m³ BaP	0.12 ng/m³ BaP	not exceed.	0.12 µg/m³	No changes

GUIDELINES WHO (2005 & 2021)

Art 10, Annex VII, measuring UFP, BC, PNSD PM composition, OP, NH_3,.....

Atmospheric pollution

1999/30/CE
PM10 standards

ANNEX III

LIMIT VALUES FOR PARTICULATE MATTER (PM_{10})

	Averaging period	Limit value	Margin of tolerance	Date by which limit value is to be met
STAGE 1				
1. 24-hour limit value for the protection of human health	24 hours	50 µg/m³ PM_{10}, not to be exceeded more than 35 times a calendar year	50 % on the entry into force of this Directive, reducing on 1 January 2001 and every 12 months thereafter by equal annual percentages to reach 0 % by 1 January 2005	1 January 2005
2. Annual limit value for the protection of human health	Calendar year	40 µg/m³ PM_{10}	20 % on the entry into force of this Directive, reducing on 1 January 2001 and every 12 months thereafter by equal annual percentages to reach 0 % by 1 January 2005	1 January 2005
STAGE 2 (1)				
1. 24-hour limit value for the protection of human health	24 hours	50 µg/m³ PM_{10}, not to be exceeded more than 7 times a calendar year	To be derived from data and to be equivalent to the Stage 1 limit value	1 January 2010
2. Annual limit value for the protection of human health	Calendar year	20 µg/m³ PM_{10}	50 % on 1 January 2005 reducing every 12 months thereafter by equal annual percentages to reach 0 % by 1 January 2010	1 January 2010

(1) Indicative limit values to be reviewed in the light of further information on health and environmental effects, technical feasibility and experience in the application of Stage 1 limit values in the Member States.

By 2010 adopting WHO guidelines

Discarded by 2008/50/CE & postponed to 2013 when the 2008/50/CE would have been reviewed

Discarded by the Clean Air Quality package in 2014 & postponed to 2024 (2030) by 2024/2881

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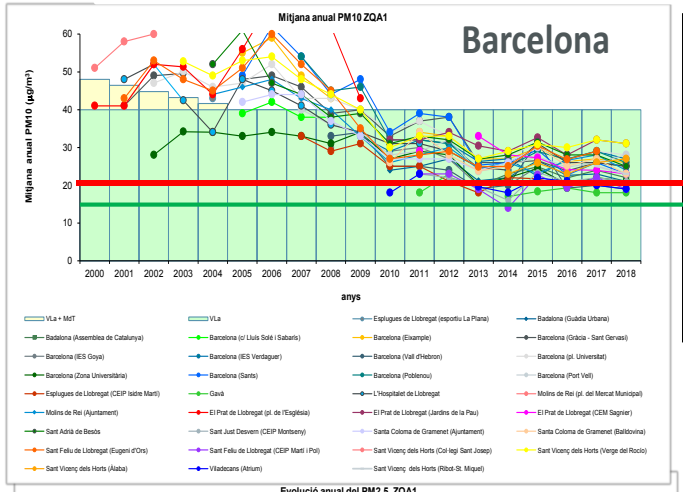
Atmospheric pollution

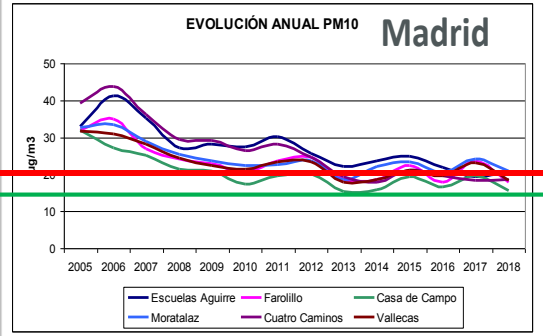
Kutlar Joss et al., 2017. 20 years of E.U. resistance against science-based «limit values» for PM10 & PM2.5 Int J Pub Health 2017

	Science-based limit values to protect human health		Politically set «limit values»				
µg/m³ Annual mean	WHO 2005 AQ Guidelines	WHO 2021 AQ Guidelines	Canada, Iceland, Iran, Australia Switzerland	State of California	USA Federal, Mexico Cuba	EU 2030	EU 2005-2029
PM_{10}	20	15	20	20	--	20	40
$PM_{2.5}$	10	5	10 (AUST: 8)	12	12	10	25

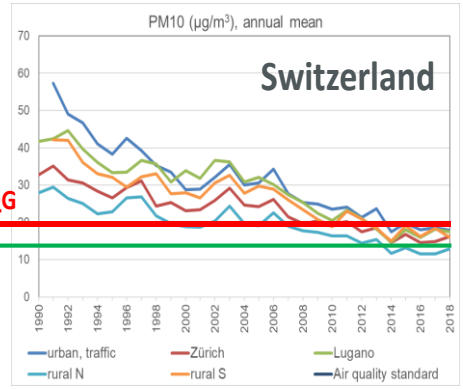
Atmospheric pollution

PM10



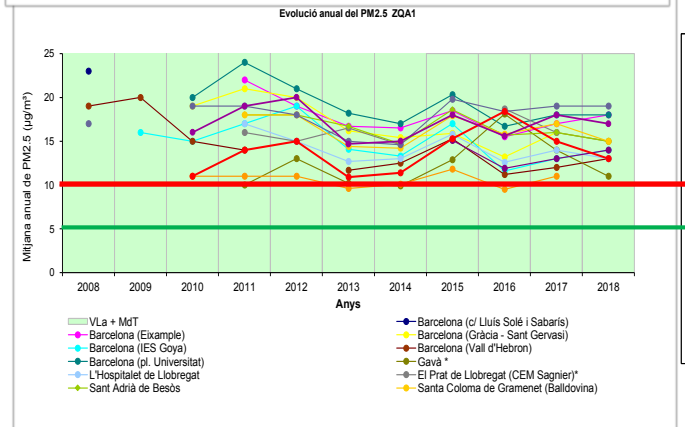


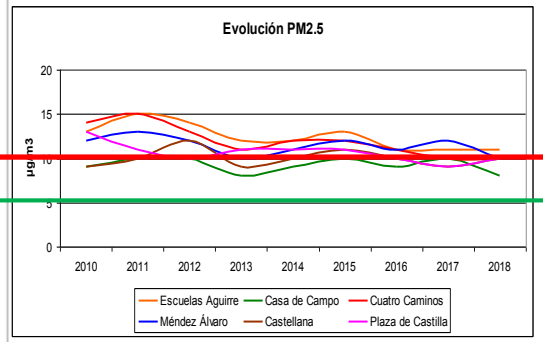
WHO AQG

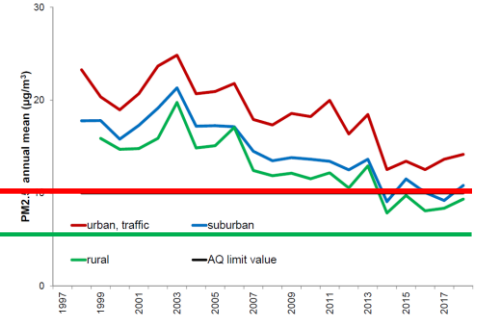


WHO AQG 2021

PM2.5







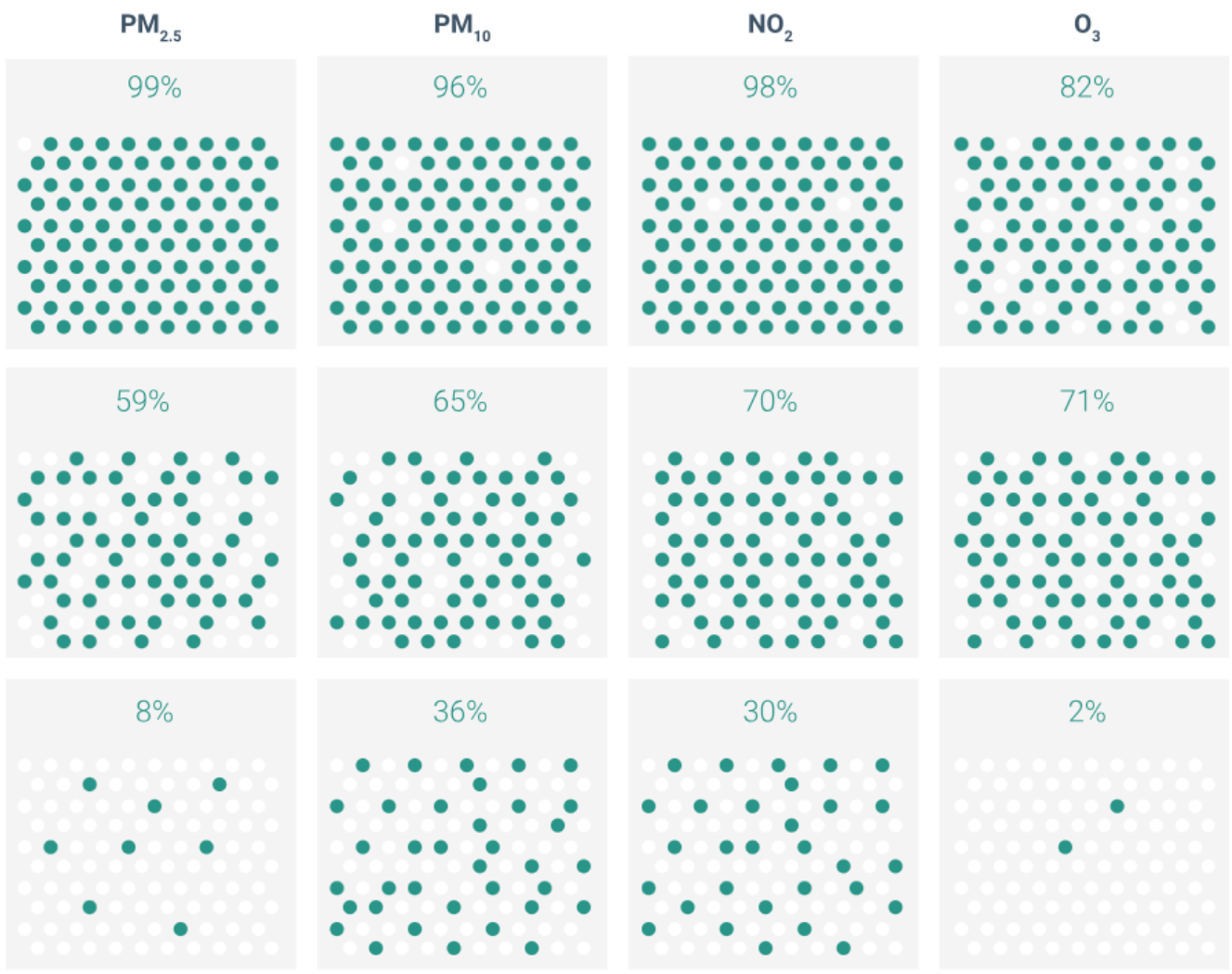
WHO AQG 2021

Atmospheric pollution

2023

European Environment Agency

Air quality in Europe 2025
April 2025



*The 2030 limit values are presented for comparative purposes only to show the distance to target to achieve these limits by 2030.

https://www.eea.europa.eu/en/analysis/publications/air-quality-status-report-2025

Country	Total population	Population above 30 years old (1,000)	$PM_{2.5}$ Annual mean (µg/m³)	$PM_{2.5}$ Attributable deaths Nr	$PM_{2.5}$ Attributable deaths Nr/10⁵	NO_2 Annual mean (µg/m³)	NO_2 Attributable deaths Nr	NO_2 Attributable deaths Nr/10⁵	Population above 25 years old (1,000)	O_3 Peak season (µg/m³)	O_3 Attributable deaths Nr	O_3 Attributable deaths Nr/10⁵
Austria	8,979	6,159	10.1	3,300	53	13.8	780	12	6,750	96.6	1,400	21
Belgium	11,617	7,625	10.1	4,100	54	15.6	1,200	16	8,356	88.4	1,400	16
Bulgaria	6,839	4,975	15.0	9,000	180	15.6	1,500	29	5,287	77.1	930	17
Croatia	3,862	2,699	14.6	3,800	141	13.2	450	16	2,914	101.0	980	33
Cyprus	1,253	799	14.8	690	86	23.9	260	33	903	91.4	140	15
Czechia	10,517	7,270	13.1	6,900	94	12.7	730	10	7,843	95.4	1,800	22
Denmark	5,873	3,802	7.8	1,200	31	7.4	50	1	4,208	80.0	540	12
Estonia	1,332	913	5.6	90	9	7.2	20	1	985	77.1	130	12
Finland	5,548	3,739	4.4	70	1	7.3	50	1	4,088	75.6	440	10
France	65,795	42,817	9.5	20,700	48	12.7	5,000	11	46,453	92.8	9,000	19
Germany	83,235	58,386	9.2	32,600	55	14.3	9,400	16	63,279	93.5	15,200	24
Greece	10,460	7,450	15.8	10,700	144	17.6	2,200	29	7,980	95.0	2,300	28
Hungary	9,689	6,668	13.8	8,600	128	14.5	1,300	19	7,274	96.5	2,000	27
Ireland	5,060	3,121	7.1	530	16	9.1	100	3	3,417	76.7	240	7
Italy	59,030	42,749	14.6	48,600	113	16.5	9,600	22	45,750	103.7	13,600	29
Latvia	1,876	1,303	8.7	820	63	9.9	120	9	1,400	77.3	220	15
Lithuania	2,806	1,958	9.8	1,500	75	10.9	180	9	2,120	77.8	320	14
Luxembourg	645	422	7.4	80	17	13.6	30	7	471	90.8	50	11
Malta	521	357	10.7	170	48	11.4	20	4	401	96.0	60	15
Netherlands	17,590	11,585	9.3	5,300	45	16.0	1,900	16	12,720	85.7	1,800	14
Poland	36,889	25,362	16.1	34,700	136	13.0	3,100	12	27,573	88.2	5,400	19
Portugal	9,848	7,041	9.3	3,600	51	11.7	710	10	7,556	88.4	1,400	18
Romania	19,042	13,001	14.3	17,900	138	16.7	3,600	27	13,960	85.3	2,800	19
Slovakia	5,435	3,695	13.9	3,700	100	11.8	260	7	4,026	93.9	700	17
Slovenia	2,107	1,481	13.5	1,300	86	12.5	140	9	1,592	99.9	340	21
Spain	45,261	31,845	10.9	18,500	58	15.9	5,500	17	34,245	92.5	6,100	17
Sweden	10,452	6,752	5.2	480	7	6.8	60	-	7,444	78.4	740	9
Albania	2,794	1,722	15.8	3,500	200	12.4	310	17	1,951	95.1	680	34
Andorra	80	52	7.8	20	28	14.3	10	11	56	82.7	10	10
Bosnia and Herzegovina	3,464	2,404	21.1	6,200	258	12.9	460	18	2,609	98.4	920	35
Iceland	376	227	3.6	<5	<1	8.4	<5	<1	258	78.3	20	7
Kosovo under UNSCR 1244/99	1,805	933	16.5	2,400	254	13.6	240	25	1,073	85.7	320	29
Liechtenstein	39	27	8.4	10	25	13.6	<5	7	30	98.5	<5	13
Monaco	38	25	10.2	10	52	17.3	<5	16	27	106.5	10	22
Montenegro	618	391	15.1	710	182	11.3	50	13	430	92.7	140	32
North Macedonia	1,837	1,197	22.8	3,600	303	15.7	330	27	1,313	76.7	210	16
Norway	5,425	3,489	5.4	350	9	7.7	80	2	3,856	79.2	380	9
San Marino	34	24	13.8	30	102	12.8	<5	8	26	97.3	10	19
Serbia	6,797	4,717	19.1	10,800	228	16.2	1,400	30	5,119	94.2	1,500	30
Switzerland	8,739	5,968	8.6	1,900	31	14.1	610	10	6,524	100.2	1,200	19
Türkiye (TR)	84,668	46,247	-	-	-	25.1	13,900	30	52,723	84.8	5,800	10
EU27	441,561	303,974	11.4	239,000	78	14.1	48,000	15	328,995	92.2	70,000	21
EEA32 (no TR)	456,140	313,686	11.2	241,000	76	-	-	-		-	-	-
EEA32	540,809	359,933	-	-	-	15.8	63,000	17	392,386	91.0	78,000	19
All countries (no TR)	473,606	325,150	11.5	269,000	82	-	-	-		-	-	-
All countries	558,275	371,398	-	-	-	15.7	66,000	17	404,992	91.1	81,000	20

All-cause mortality 2022, EU-27

Premature mortality from all natural causes (i.e. excluding accidental and other non-natural causes), which are attributable to long-term exposure to key air pollutants.

In 2022 in the EU-27:

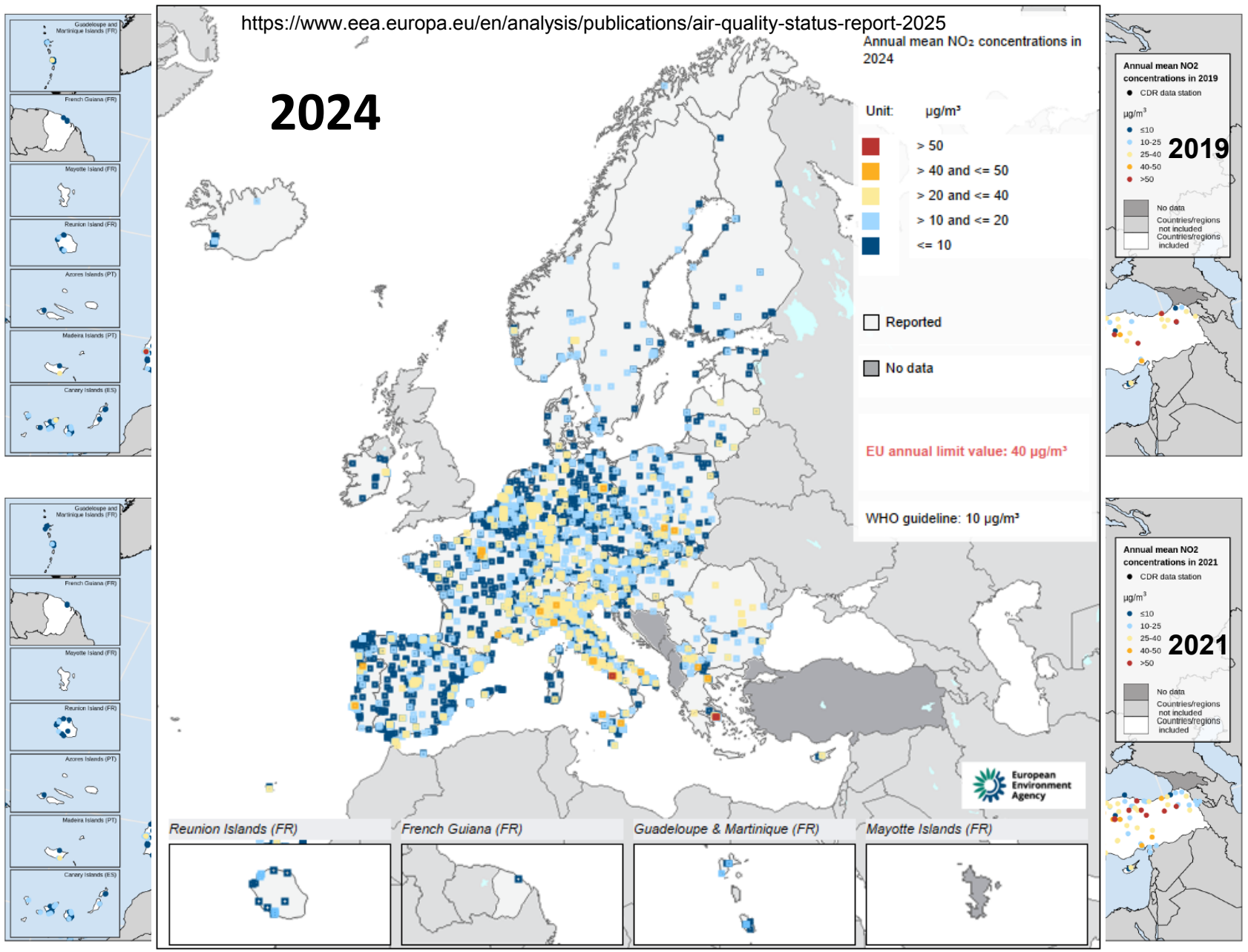
- 239,000 deaths were attributable to exposure to $PM_{2.5}$ concentrations above the WHO guideline level of 5µg/m³ .
- 70,000 deaths (95% CI: 0-137,000) were attributable to exposure to O_3 concentrations above the WHO guideline level of 60µg/m³.
- 48,000 deaths (95% CI: 24,000-95,000) were attributable to exposure to NO_2 concentrations above the WHO guideline level of 10µg/m³.

Harm to human health from air pollution in Europe: burden of disease status, 2024
December 2024

European Environment Agency

https://www.eea.europa.eu/en/analysis/publications/harm-to-human-health-from-air-pollution-2024

The problem of NO_2



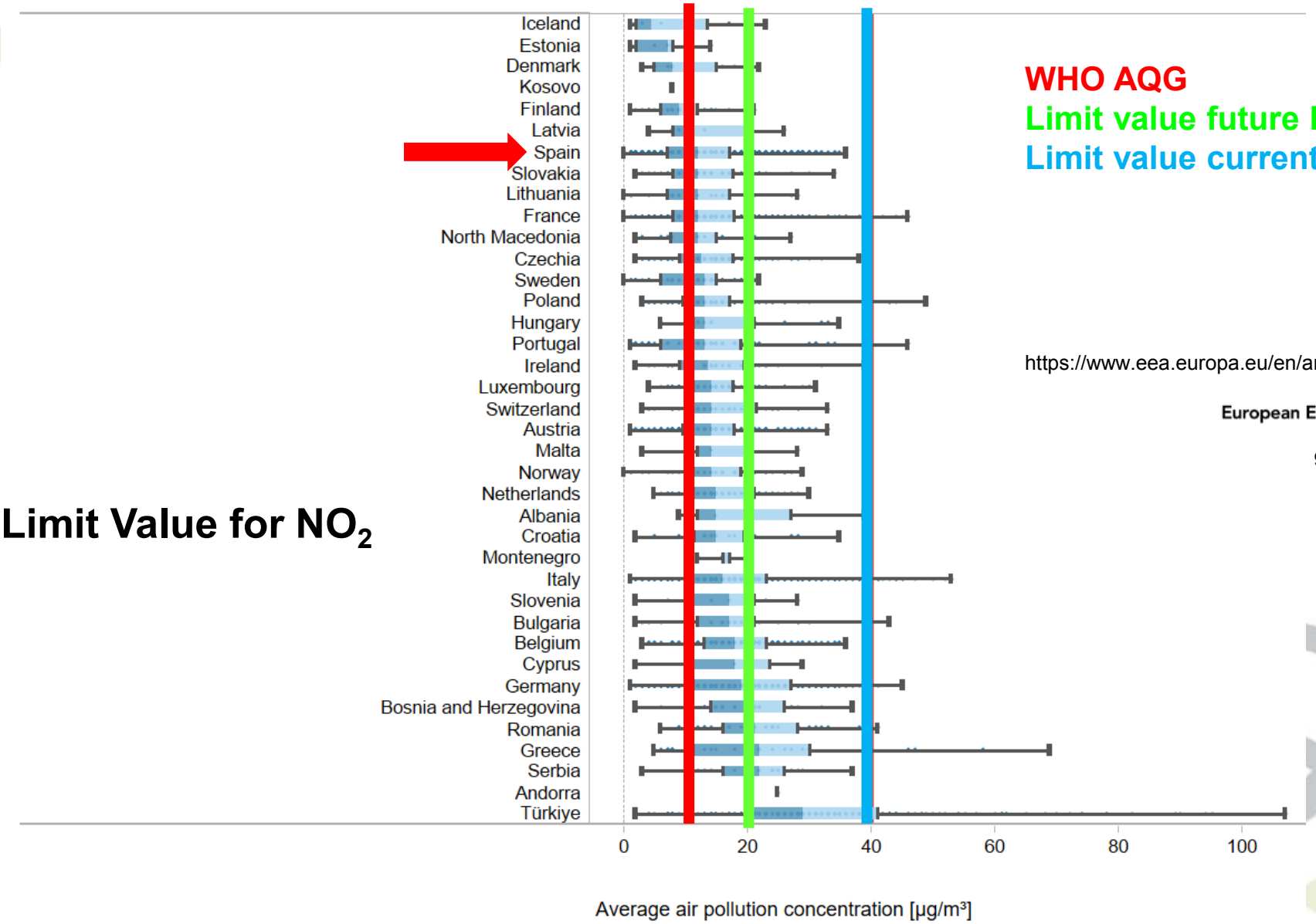
NO_2, annual

European Environment Agency

April 2025

The problem of NO_2

2023
Annual Limit Value for NO_2



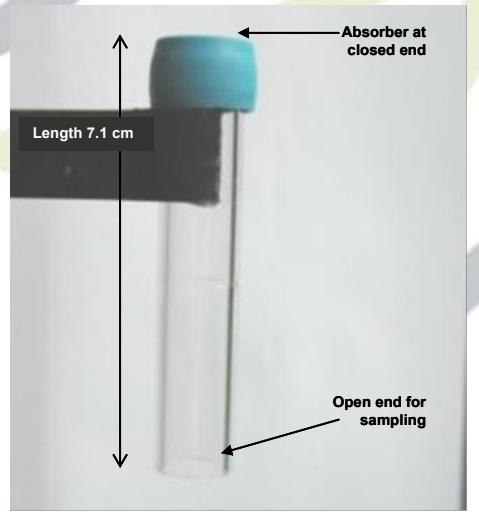
WHO AQG
Limit value future EU AQ Directive
Limit value current EU AQ Directive

https://www.eea.europa.eu/en/analysis/publications/air-quality-status-report-2025

European Environment Agency

9th April 2025

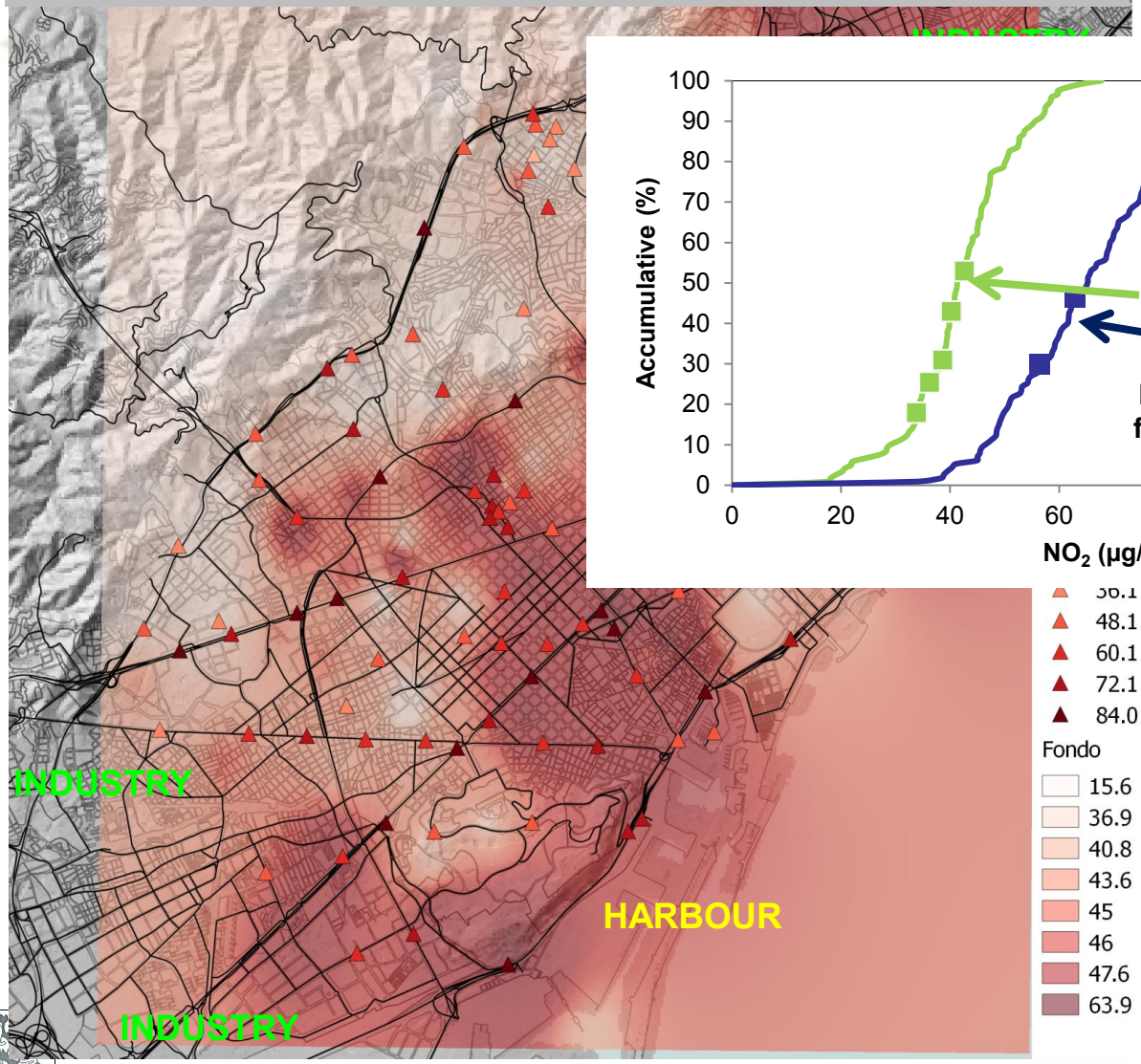
The problem of NO_2



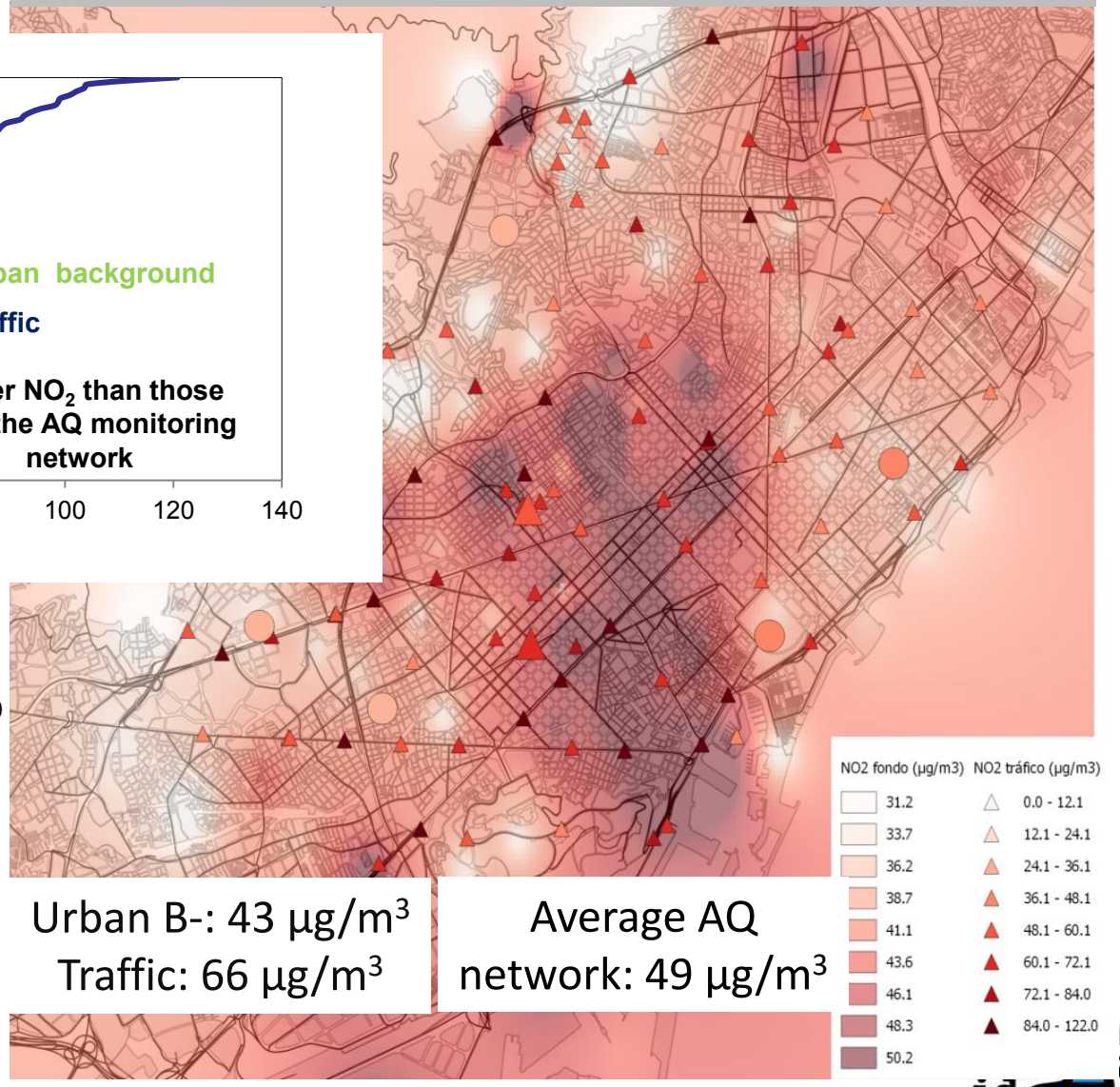
- Dosimeter NO_2 Palmes
- Molecular diffusion
- Absorbent = 20% TEA in H_2O
- Analysis: colorimetry

The problem of NO_2

NO_2 FEBRUARY-MARCH 2017, 225 PASSIVE DOSIMETERS



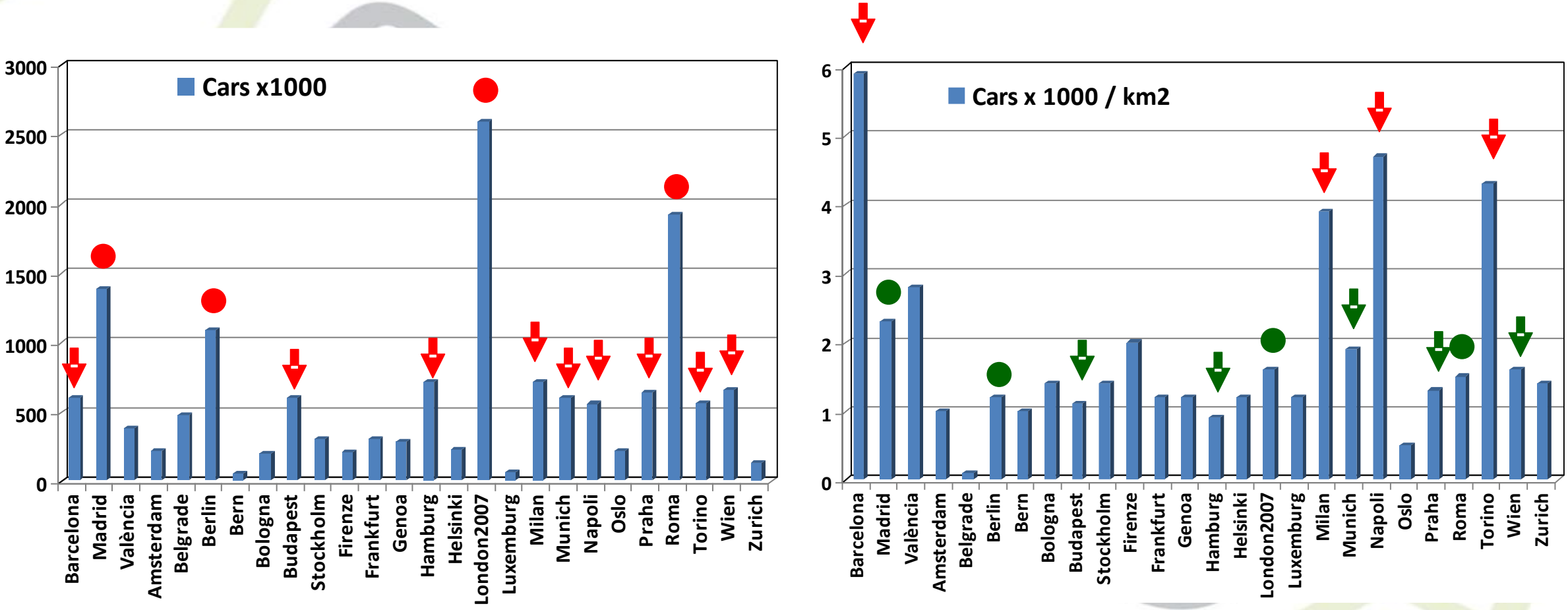
NO_2 JUNE 2018, 233 PASSIVE DOSIMETERS



Urban B-: 43 µg/m³
Traffic: 66 µg/m³

Average AQ network: 49 µg/m³

Why so high NO_2?



Very high density of vehicles (#/km²),
But also >50% of vehicles circulating in the city come from outside

The problem of NO_2

Why so high NO_2?

Ámsterdam

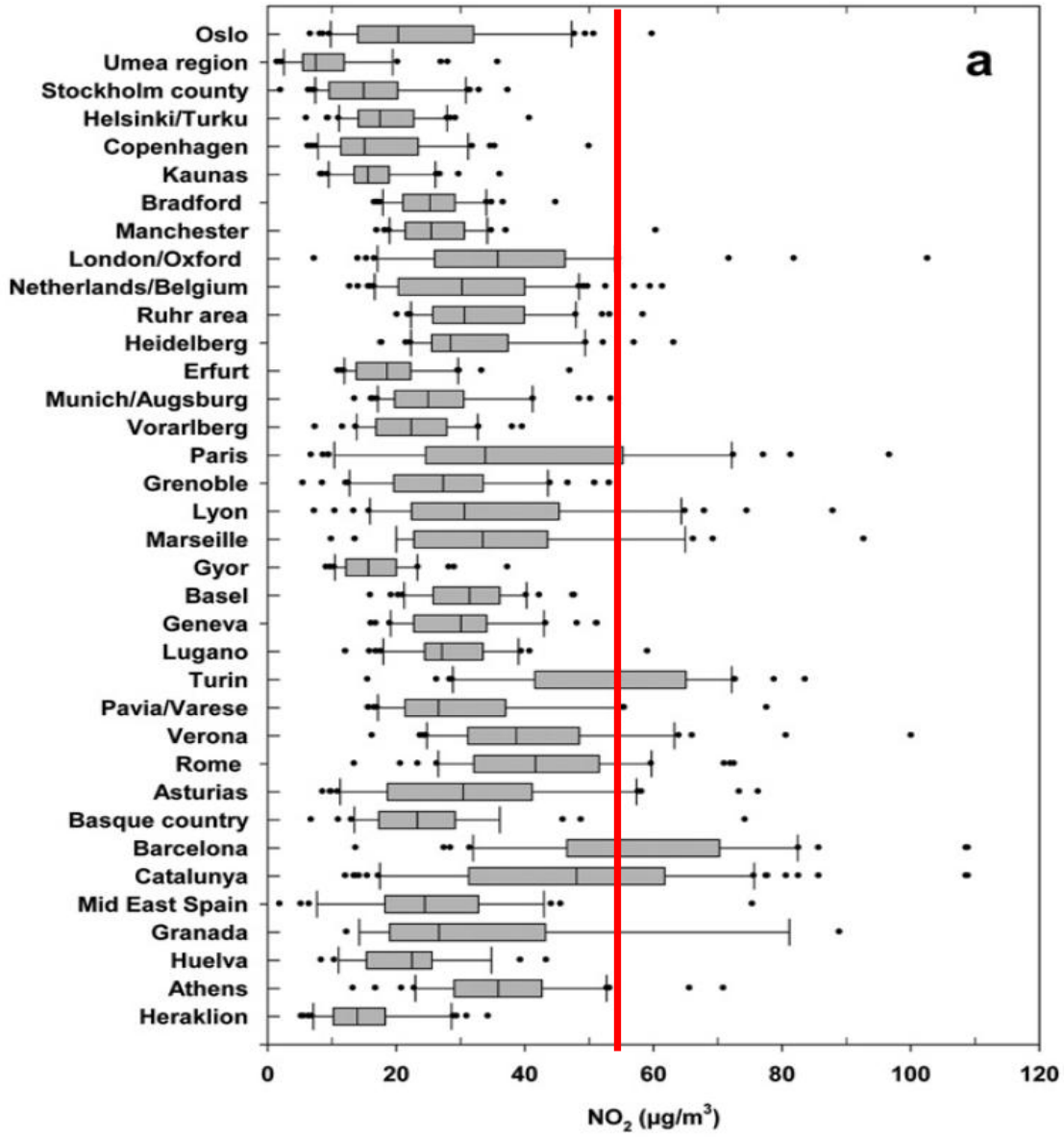
Madrid

Barcelona

Napoli

The problem of NO_2

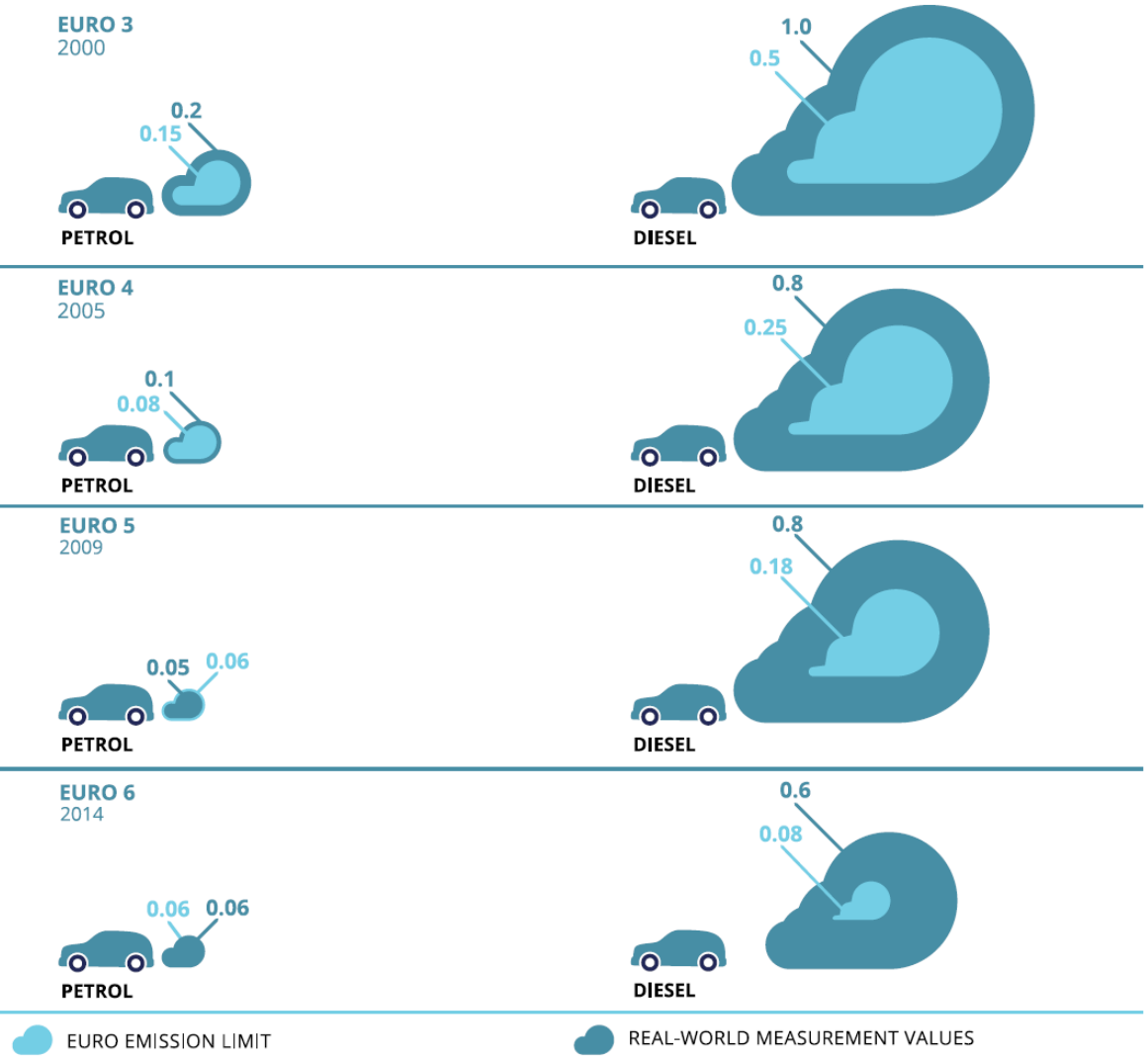
Why so high NO_2?



J. Cyrys et al. / Atmospheric Environment 62 (2012) 374–390

The problem of NO_2

Figure 6.3 Comparison of NO_x standards and emissions for different Euro classes



EEA Report | No 28/2016

23/11/2016

European Environment Agency

http://www.eea.europa.eu/publications/air-quality-in-europe-2016

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idaea

The problem of PM

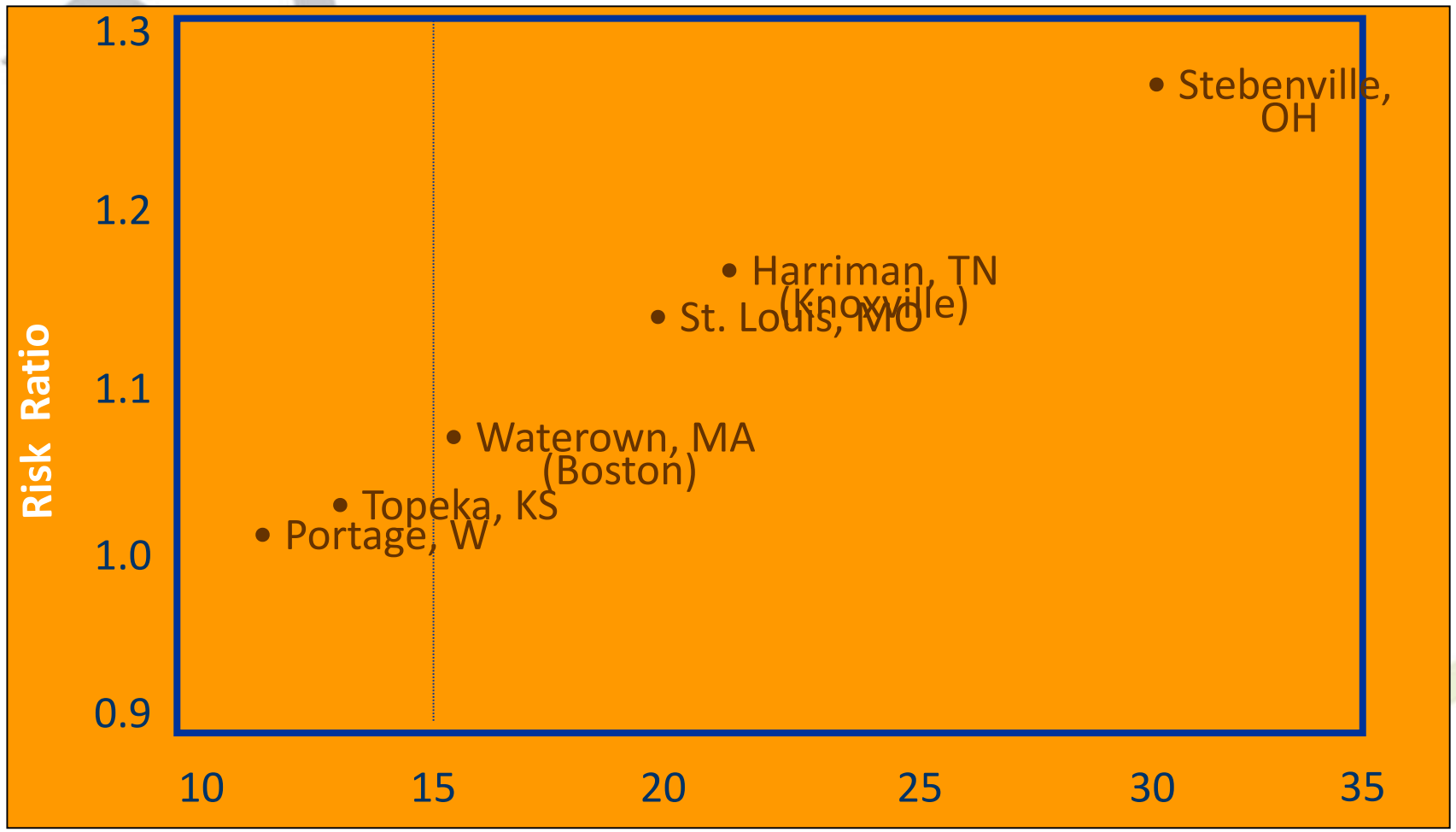
Atmospheric particulate matter (PM): **heterogeneous solid and/or liquid material present in suspension into the atmosphere**

- **Health impact**
- **Ecosystems**
- **Climate change**
- **Building materials**
- **Visibility**

The problem of PM

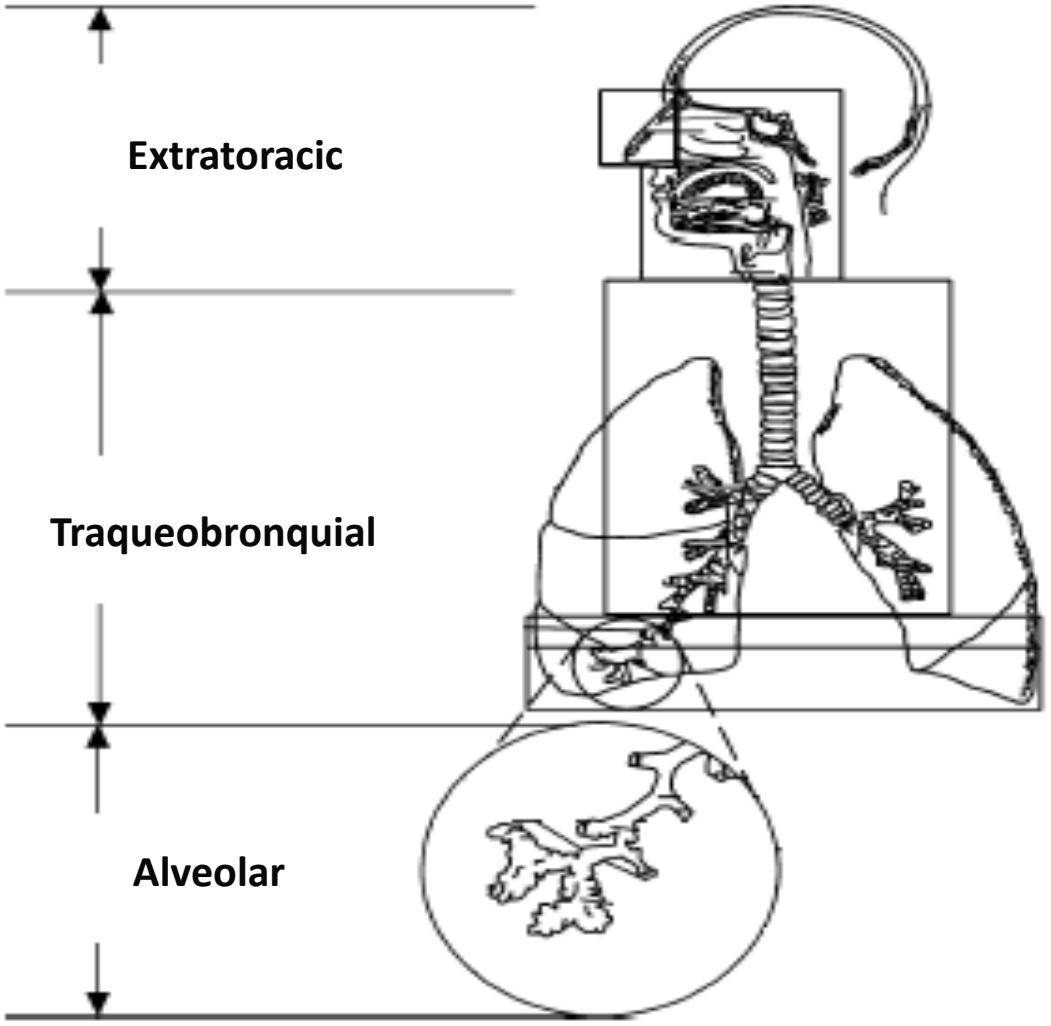
The six cities study:

$PM_{2.5}$ –MORTALITY (Dockery , NEJM 1993)



The problem of PM

PM EFFECTS



> PM10

PM10-2.5

< PM2.5

PM10-2.5
Allergens,
inflammation, oxidative stress
Happo et al., 2008
Javala et al., 2008
Pérez et al., 2009

PM2.5-0.1
Additional lung physical effect

PM0.1
Cardiovascular, UFPM
Reaching all important organs

The problem of PM

Particulate Matter and health effects in Barcelona

Perez et al., 2009 ES&T

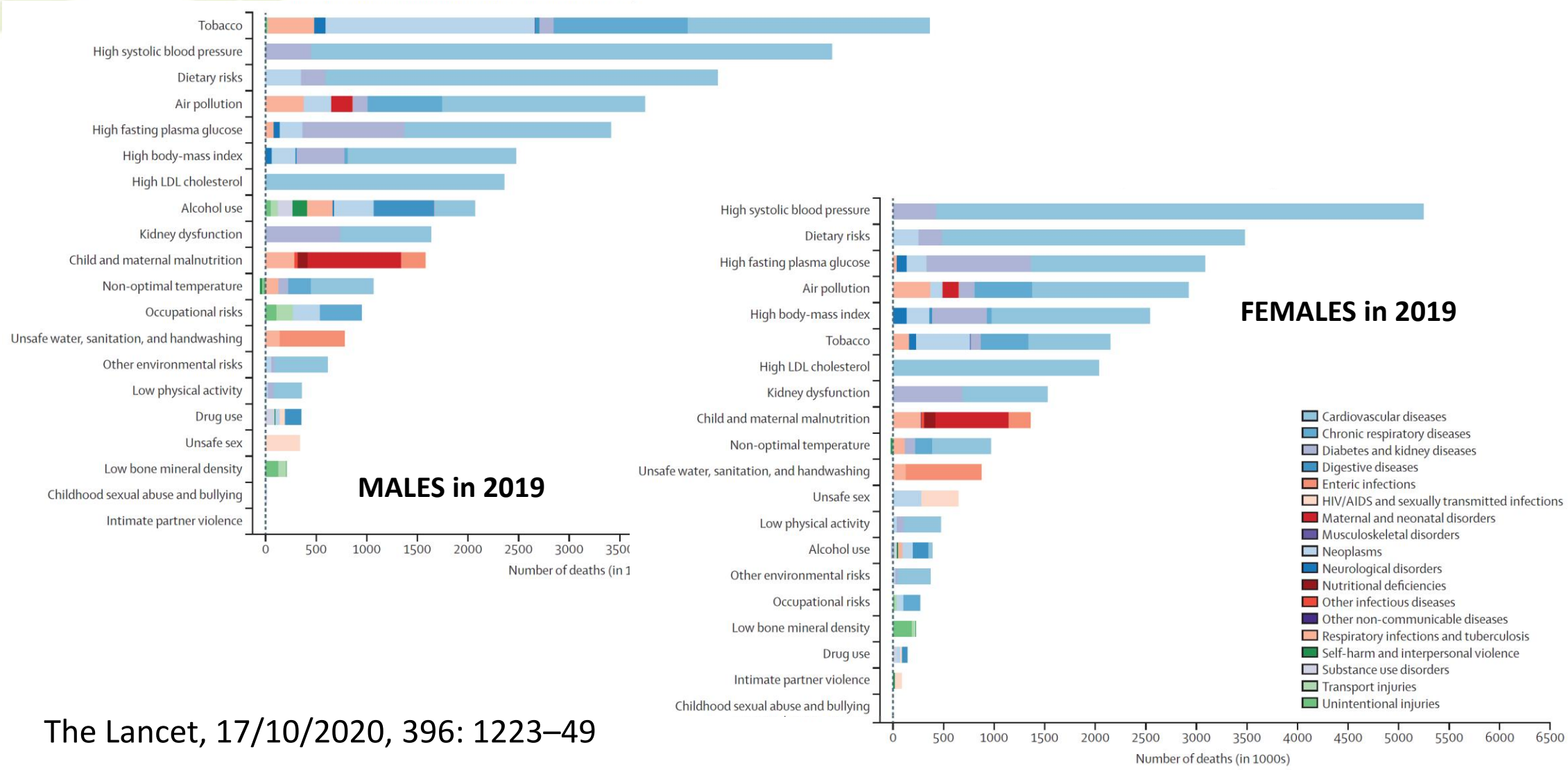
Selected results

Odds ratio per 10 ug/m3

Fraction	Respiratory mortality (Lag2)	Cardiovascular mortality (Lag1)	Cerebrovascular mortality (Lag1)
$PM_{10-2.5}$	1.033 (0.980-1.089)	**1.059 (1.026-1.094)**	**1.098 (1.030-1.171)**
$PM_{2.5-1}$	**1.206 (1.028-1.416)**	0.984 (0.892-1.086)	0.905 (0.743-1.102)
PM_{1}	1.010 (0.963-1.059)	**1.028 (1.000-1.058)**	**1.063 (1.004-1.124)**

The problem of PM

Global attributable deaths from Level2 risk factors



The Lancet, 17/10/2020, 396: 1223–49

Global burden of 87 risk factors in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019

The problem of PM

PM EFFECTS
Impact on ecosystems

Slamba Poremba, Poland (C. Martin, The Environmental Picture Library)

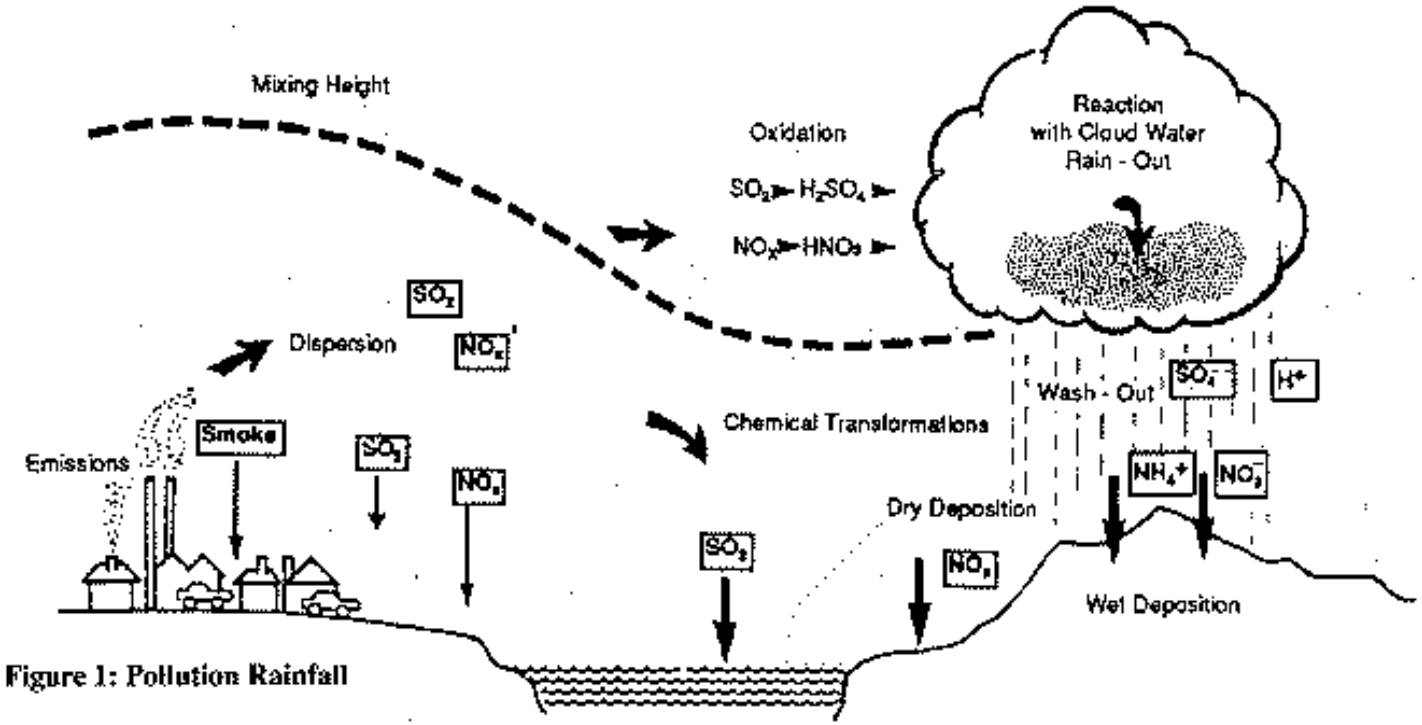
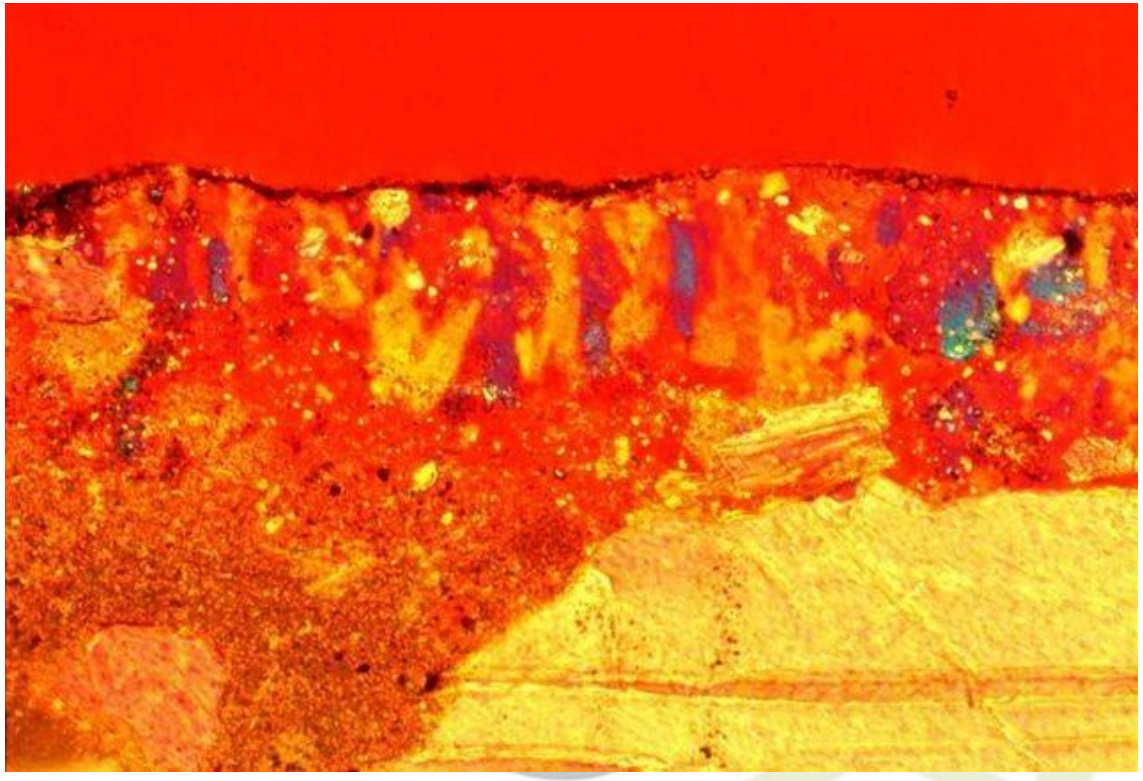


Figure 1: Pollution Rainfall

The problem of PM

PM EFFECTS

Weathering of building materials

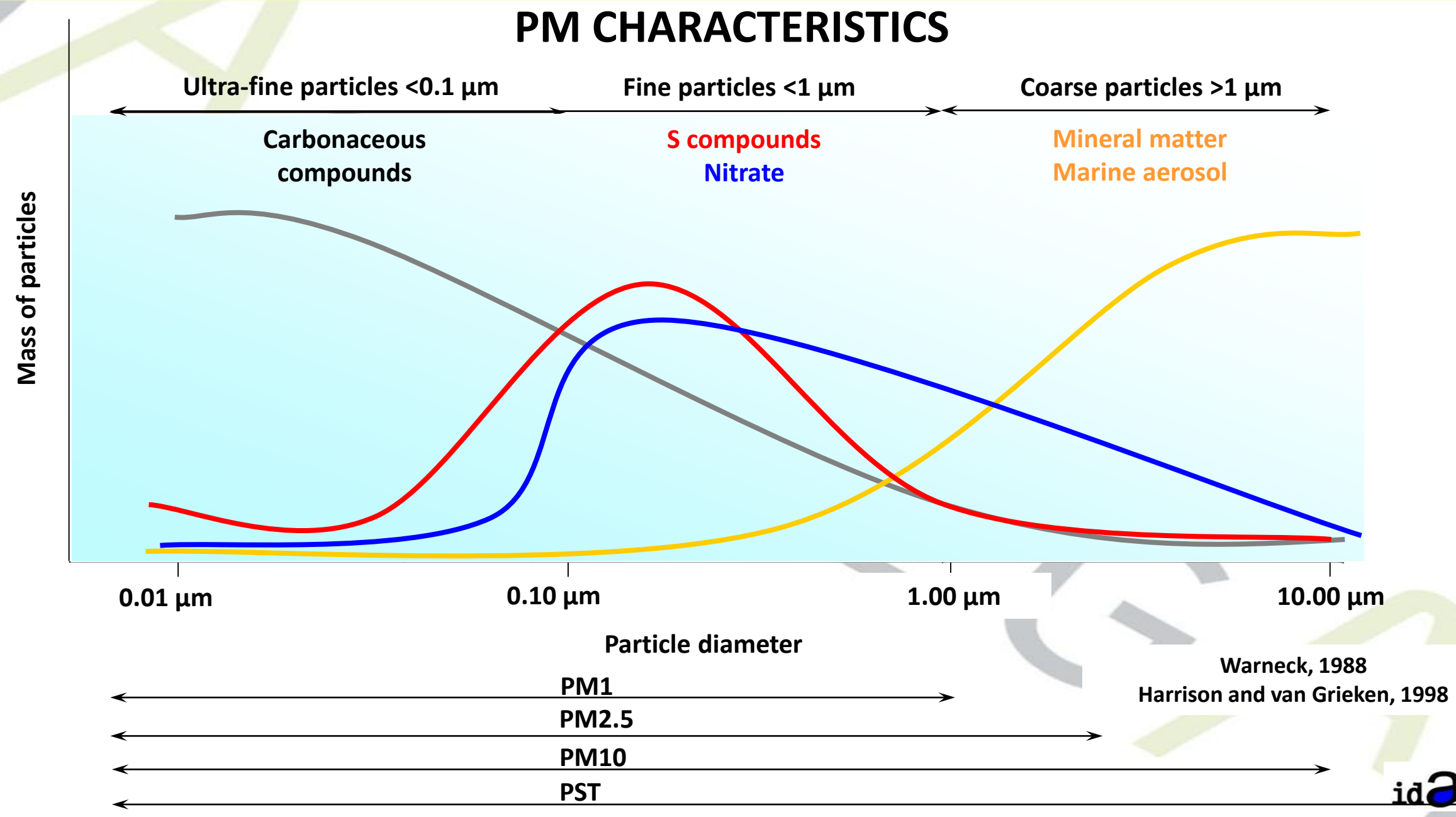


The problem of PM

PM EFFECTS

VISIBILITY

The problem of PM



The problem of PM

CLASSIFICATION OF ATMOSPHERIC PARTICLES

1. Process of formation:

Primary particles: directly emitted to the atmosphere as a solid

Secondary particles: produced into the atmosphere from gaseous precursors

example: SO_2 (g) $\xrightarrow{\text{oxidation}}$ SO_4^{2-} (s)

2. Origin:

Natural particles

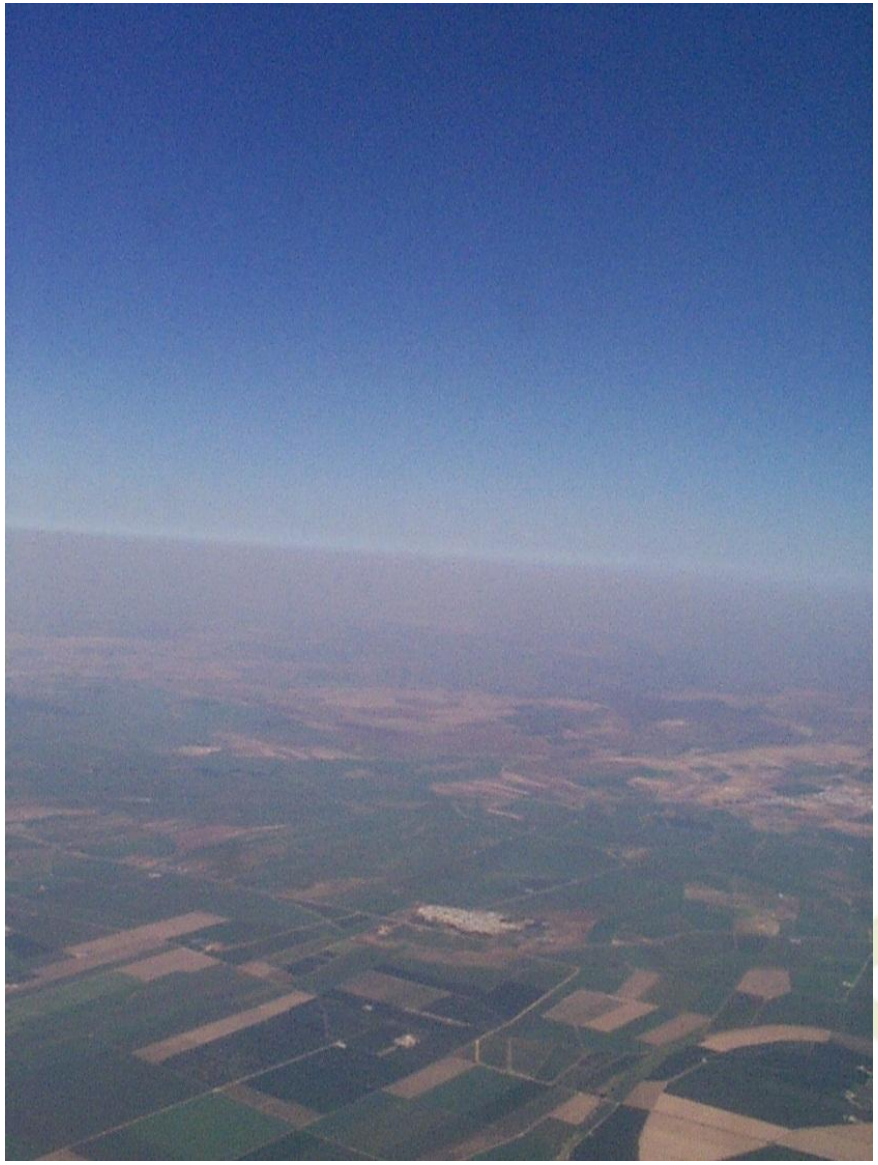
Anthropogenic particles (human activities)

The problem of PM

PRIMARY PM

The problem of PM

SECONDARY PM



The problem of PM

FORMATION OF SECONDARY AEROSOLS

SECONDARY INORGANIC AEROSOLS

GAS			GAS ACIDIC		GAS ALKALINE		PM2.5
SO_2 NO_x	+ Photochemistry	⟹	HNO_3 H_2SO_4	+	NH_3	⟹	NH_4NO_3 $(NH_4)_2SO_4$

SECONDARY ORGANIC AEROSOLS

GAS		PM2.5
VOLATILE ORGANIC COMPOUNDS + OH (or O_3)	⟹	ORGANIC MATTER
(BETX, OTHER AROMATICS, TERPENES, ALDEHYDES,…)		

The problem of PM

PM ORIGIN

PRIMARY

- **Natural**

  re-suspension (loc/ext)
  evap./precip.

- **Anthropogenic**

  direct emissions

  fugitive emissions

SiO_2,Al_2O_3,Fe_2O_3,TiO_2

$CaCO_3$, NaCl, C_{org}, metals

SECONDARY

- **Natural**

  natural sulphate

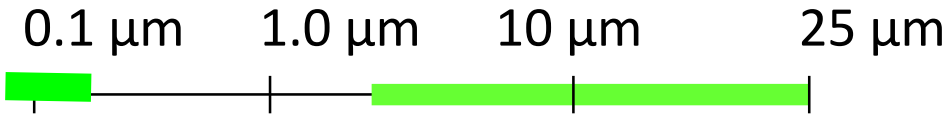
  biogenic emissions

- **Anthropogenic**

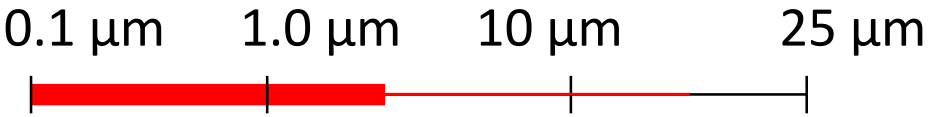
  PM from gas by nucleation
  condensation evaporation

$SO_4^{=}$, NO_3^{-}, NH_4^{+}, H^{+}

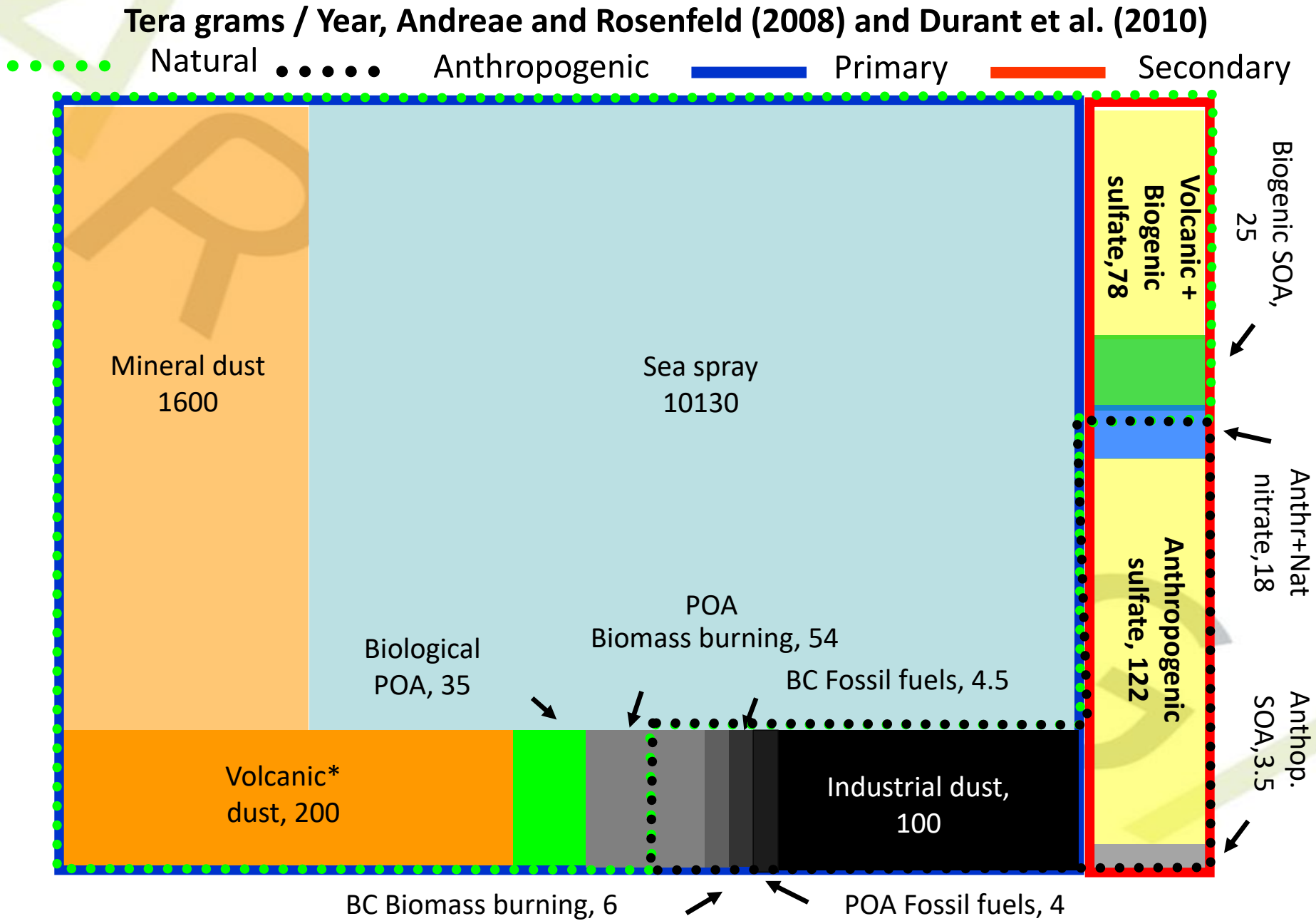
C_{org}, metals



(Soot)



The problem of PM



The problem of PM

PM ORIGIN

Crustal-mineral

Al_2O_3
Mg
Ti
Fe
K
SiO_2
CO_3^{2-}
P
Ca

Sea spray

Na^+
Cl^-
SO_4^{2-}

Carbonaceous aerosols (OM and EC)

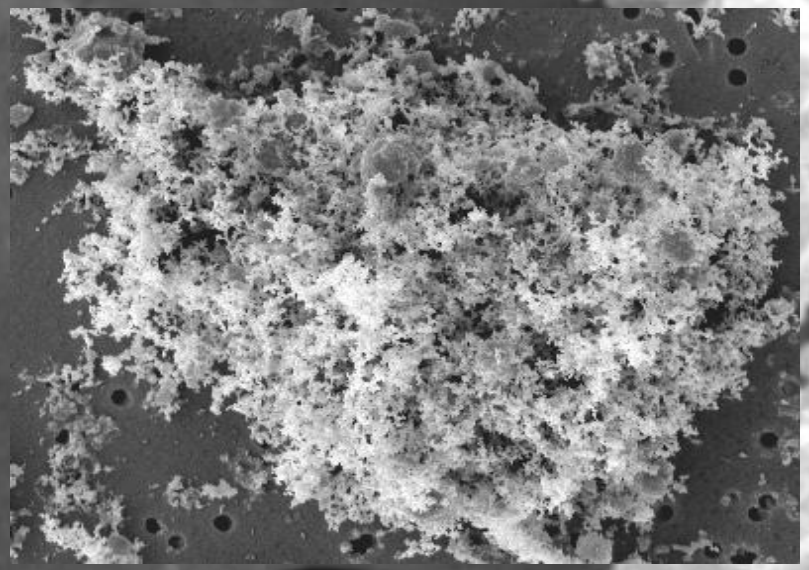
Secondary Inorganic aerosols

NH_4^+
SO_4^{2-}
NO_3^-

Trace elements

As, Ba, Bi, Cd, Ce, Co, Cr, Cs, Cu, Dy, Er, Ga, Gd, Ge, Hf, La, Li, Mn, Mo, Nd, Ni, Pb, Pr, Rb, Sb, Sc, Se, Sm, Sn, Sr, Ta, Th, Ti, Tl, U, V, W, Yb, Zn, Zr

Diesel soot



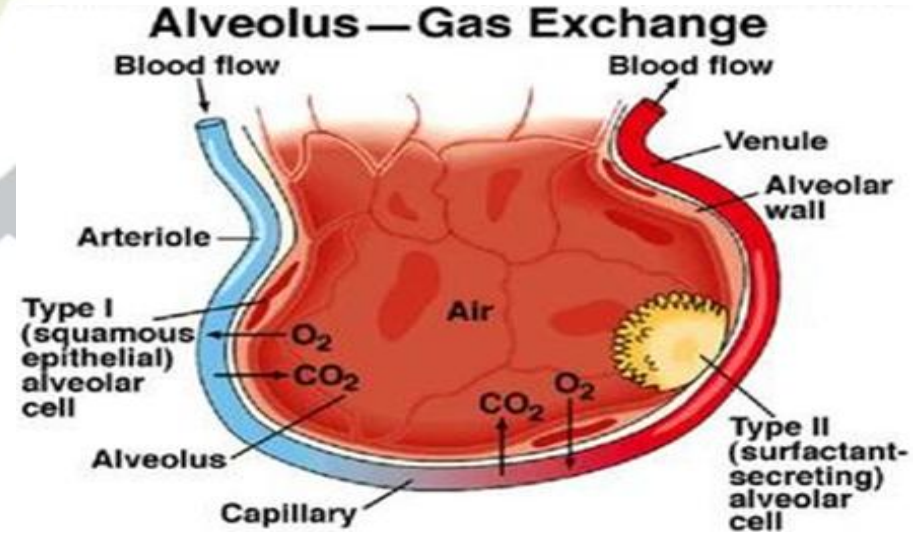
‘soot’

Vehicle exhaust

Acc.V Spot Magn Det WD Exp 1 µm

The problem of PM

Micro-particles <2.5µm

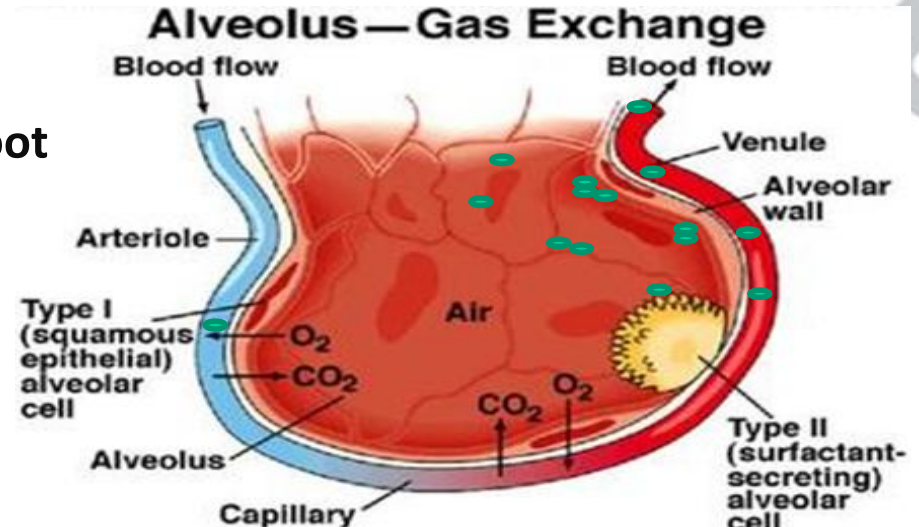


Modified after https://birdrespiratory.weebly.com/gas-exchange.html

Clearance within 6-14 hr

Ultrafine-particles <0.1µm

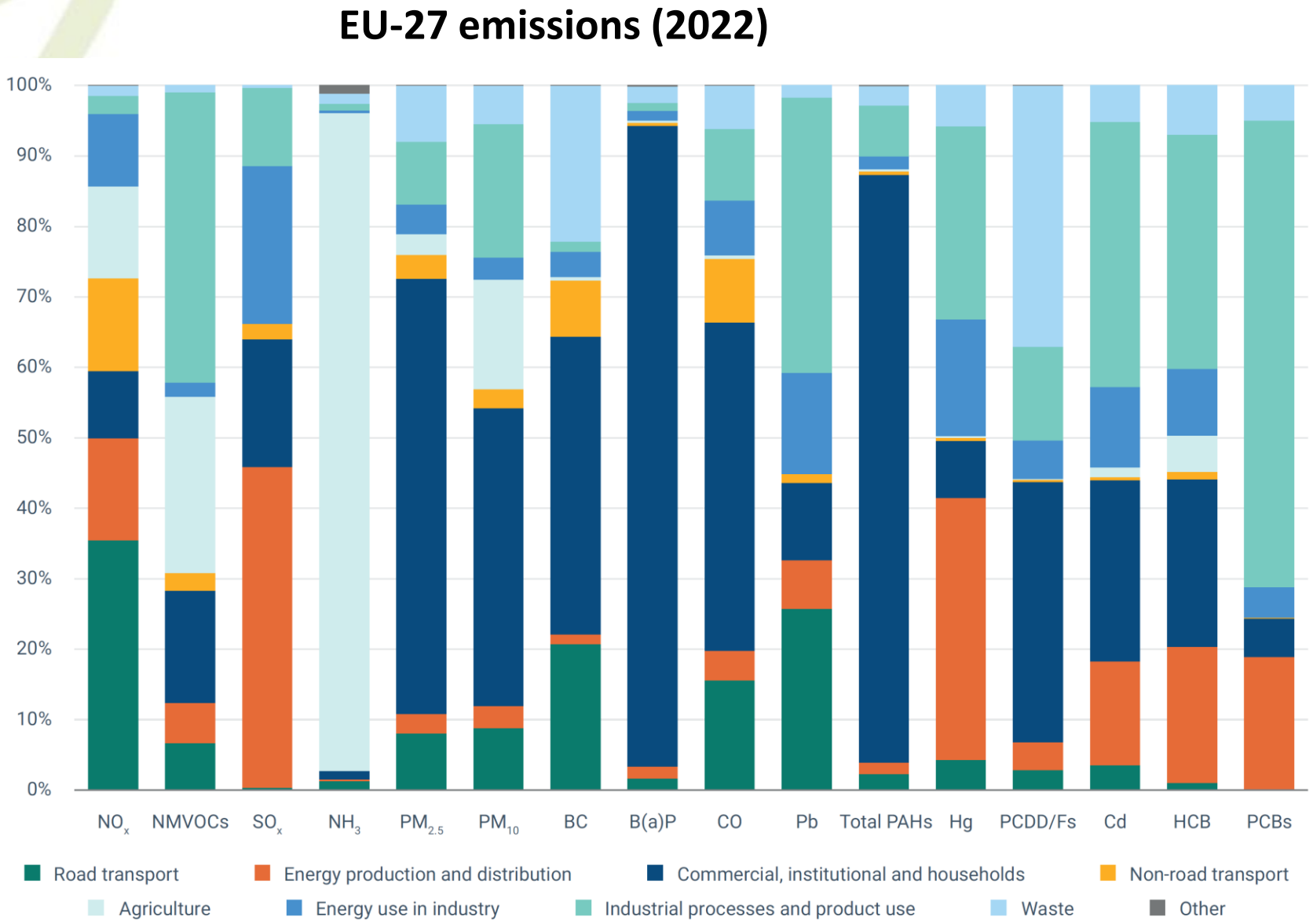
Stadium size= pollen
Football ball = diesel soot



UFP uptake by epithelial cells +
interstitial translocation +
lack of macrophage recognition

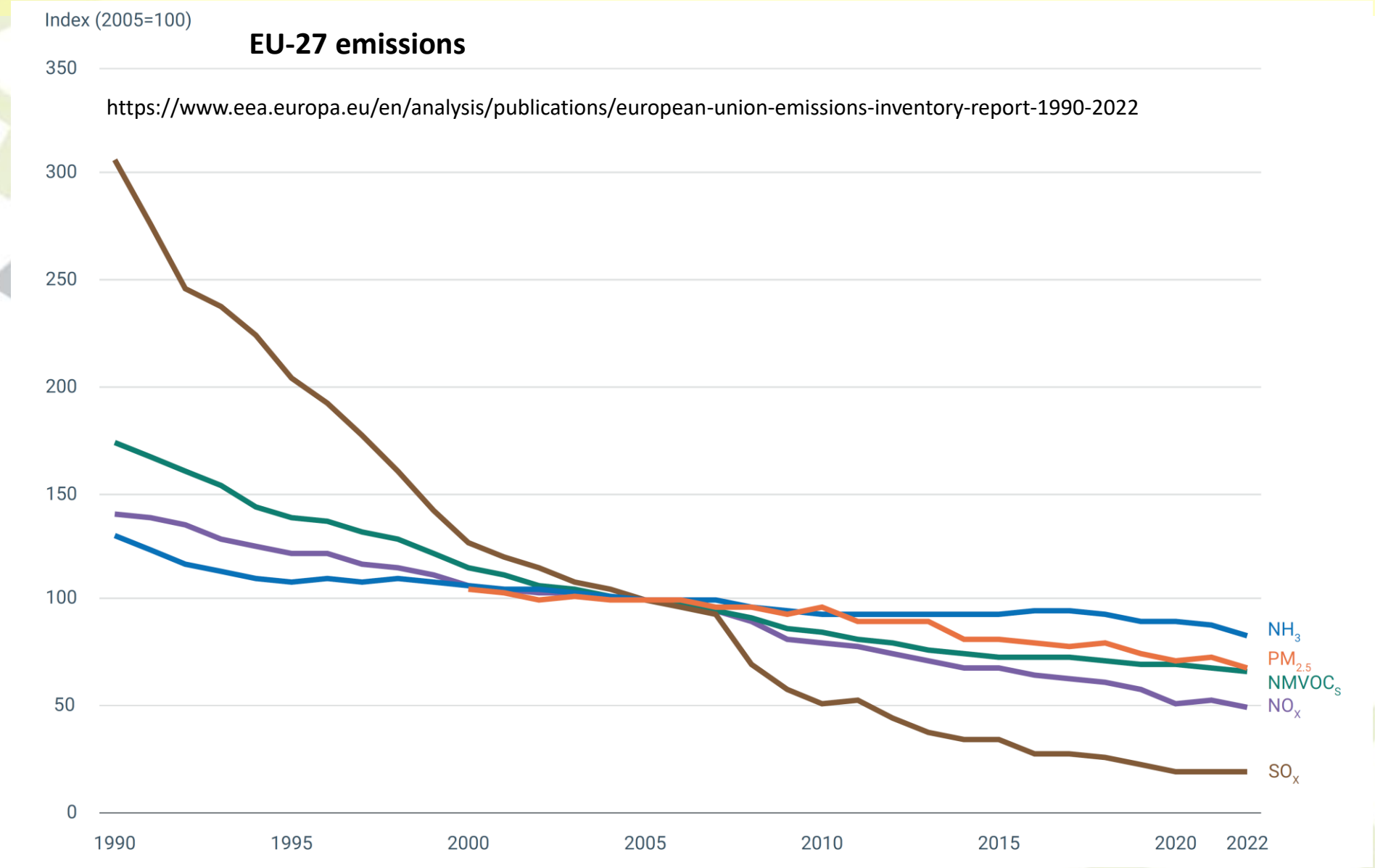
F.R. Cassee | AAAR 2019

The problem of PM



Does these proportions reflects the contribution to human exposure for each pollutant?

The problem of PM



European Environment Agency

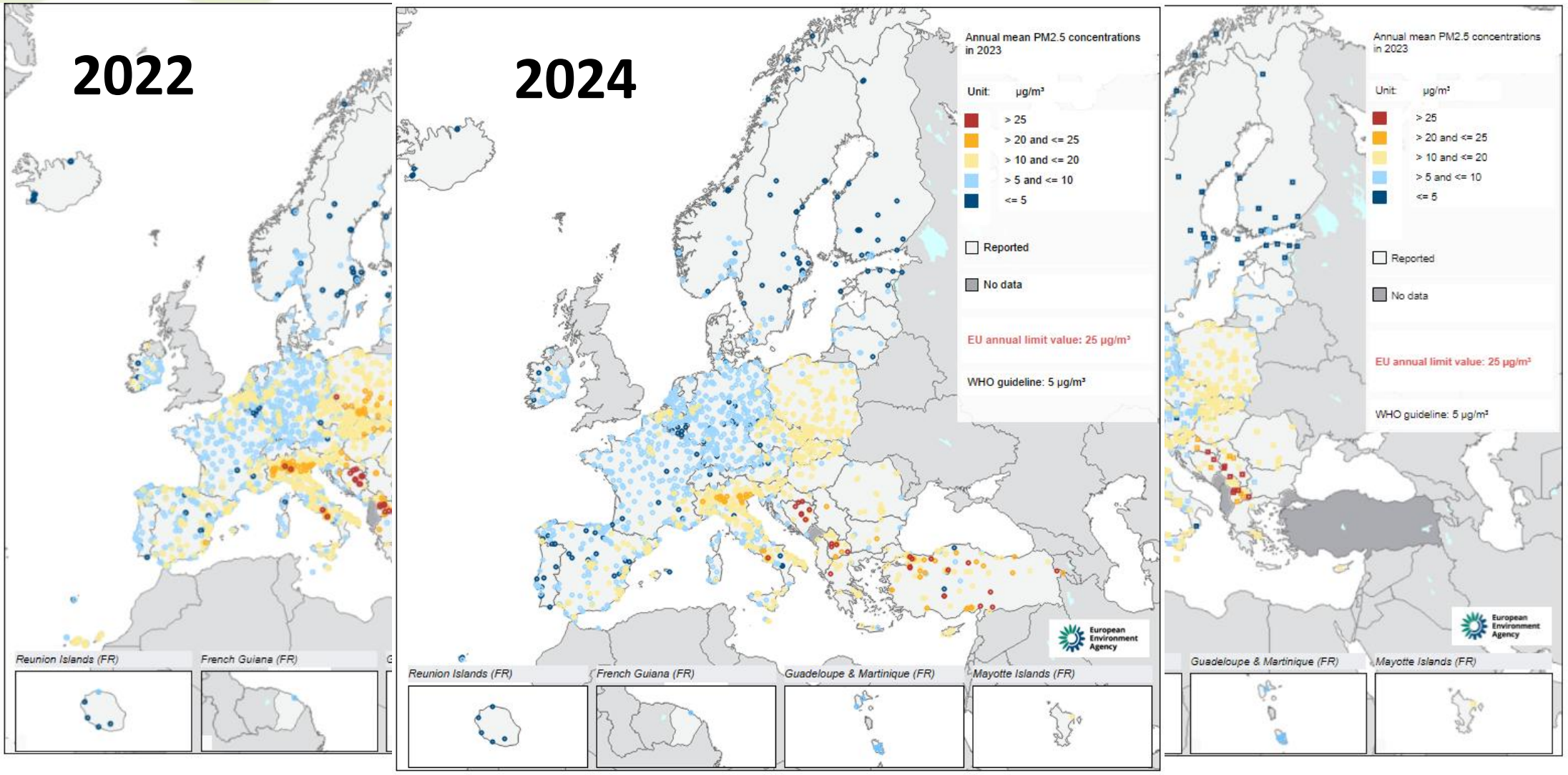
The problem of PM

PM2.5, annual mean

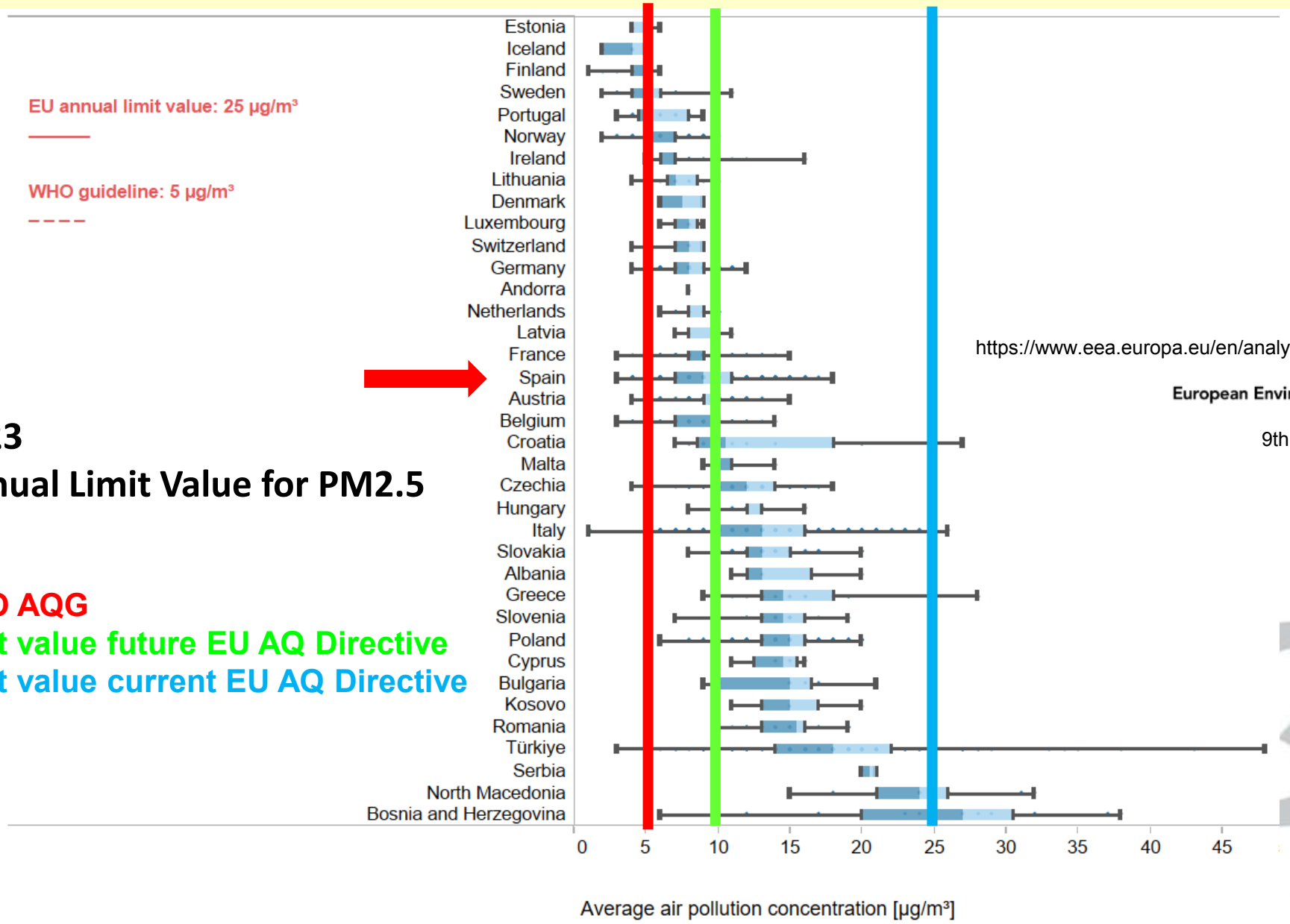
https://www.eea.europa.eu/en/analysis/publications/air-quality-status-report-2025

European Environment Agency

9th April 2025



The problem of PM



2023

Annual Limit Value for PM2.5

WHO AQG

Limit value future EU AQ Directive

Limit value current EU AQ Directive

https://www.eea.europa.eu/en/analysis/publications/air-quality-status-report-2025

European Environment Agency

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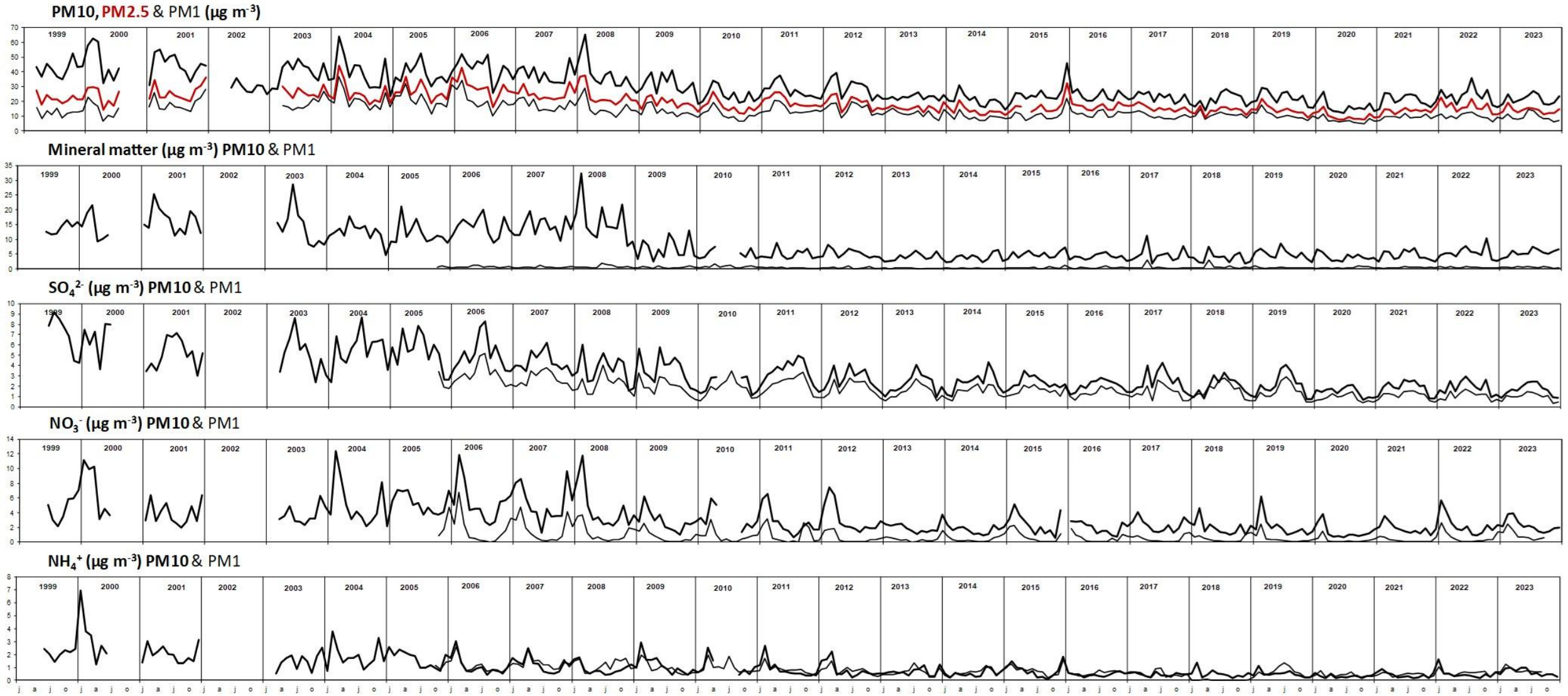
The problem of PM

PM10 (annual mean)	PM10 (days of exceedance)
1. Road Traffic is the main source contributing to PM10: 31-38% (ATH 23%)	36-45% (ATH 15%)
1.1. Vehicle exhaust + traffic related NO_3^- are the main causes: 21-29% (ATH 15%)	30-34% (ATH 6%)
1.2. Non-exhaust vehicle emissions are also relevant: 8-11%	18-29% (ATH 3%, POR 6%)
2. Regional OC and/or SO_4^{2-} dominated pollution: 20-26% (POR-TR 10%)	BCN 19%, 2-6%
3. Local dust : 10-19%	POR 27%, 1-4%
4. Biomass burning very relevant in POR & FI (14-16%), less in ATH (7%) and negligible in BCN	POR & FI (25-30%), ATH 1%, negligible in BCN
5. Industry BCN 11%, 4-5%, ATH <1%	BCN 17%, <1-3%
6. Non traffic-NO_3^- 6-8% (2% POR)	BCN & FI 7-9% (1-2% POR & ATH)
7. Shipping 4% in coastal sites	3-4% in coastal sites
8. African dust ATH 14%, 1-4%	ATH 52%, 1%
9. Sea salt POR 13%, 4-8%	ATH 7%, 1-3%
10. Anthropogenic dust (Local dust + Non exhaust) reaches 19-25%	11-33%, ATH 4%

PM2.5 (annual mean)	PM2.5 (days of PM10 exceedance)
1. Road Traffic is the main source contributing to PM2.5: 28-39% (ATH 22%)	32-42% (ATH 11%)
1.1. Vehicle exhaust + traffic related NO_3^- are the main causes: 25-34% (ATH 17%)	31-40% (ATH 10%)
1.2. Non-exhaust vehicle emissions are also relevant: 5-9% (BCN&FI 1-2%)	1-7%
2. Regional OC and/or SO_4^{2-} dominated pollution: 19-37% (POR 13%)	BCN & MLN 11-22%, 2-6%
3. Local dust: POR 16%, 2-6%	POR 22%, 1-2%
4. Biomass burning very relevant in MLN, FI & POR (18-21%), less in ATH (10%) and negligible in BCN	POR, FI & MLN (26-33%), <2%
5. Industry 5-12%, ATH <1%	BCN 18%, <1-3%
6. Non traffic-NO_3^- 3-6% (POR 1%)	BCN, FI & MLN 6-9% (1-3% POR & ATH)
7. Shipping 5-7% in coastal sites	6-10% in coastal sites
8. African dust: ATH 6%, <1%	ATH 45%, 1%
9. Sea salt POR 5%, <1-3%,	<1%-1%
10. Anthropogenic dust (Local dust + Non exhaust) reaches 10-21%, BCN 7%, FI 4%	POR 15, 3-9%

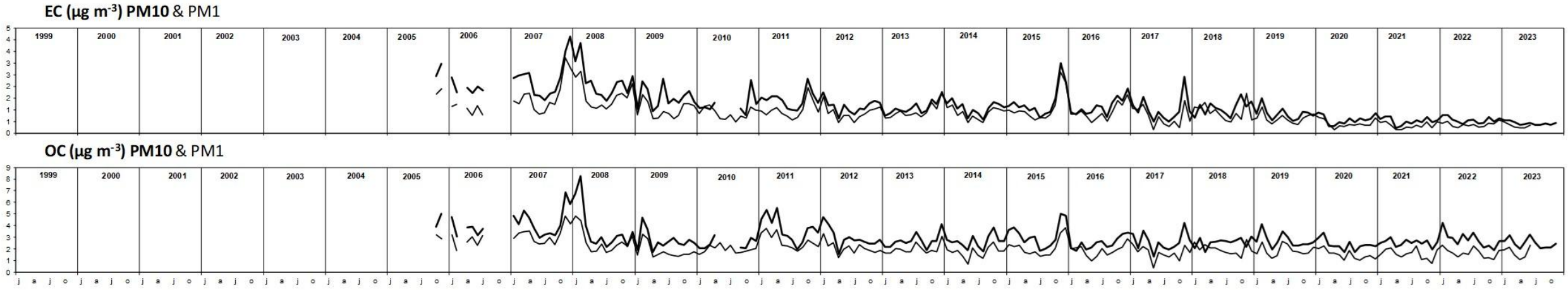
The problem of PM

BARCELONA PM & PM COMPONENTS 1999-2023

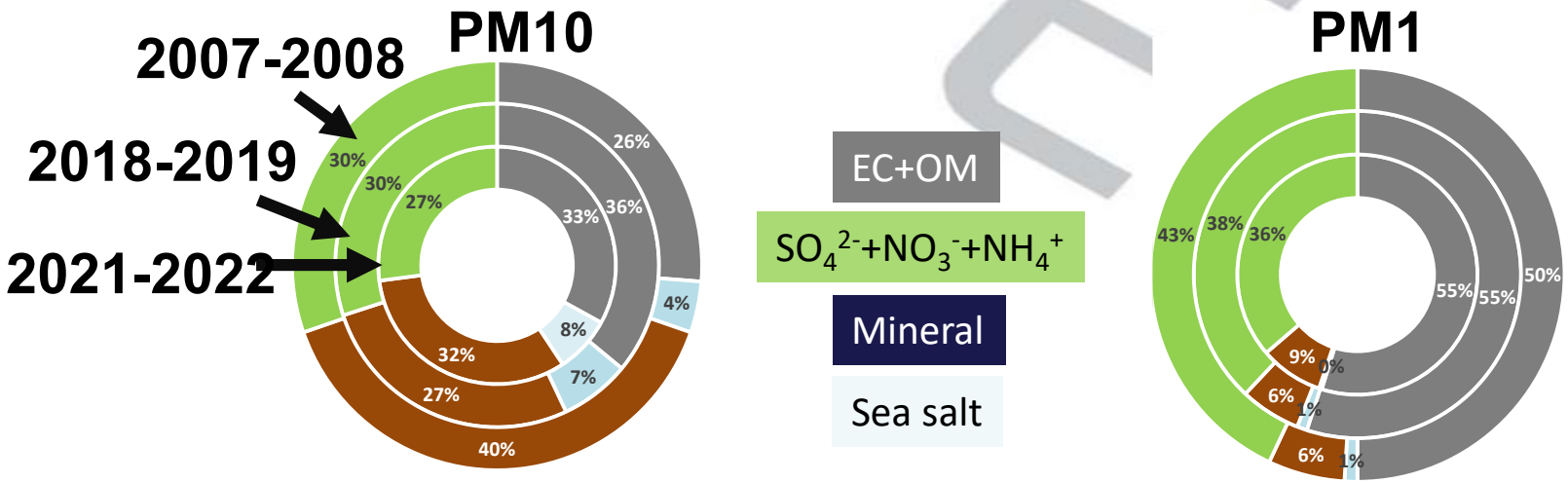


The problem of PM

BARCELONA PM & PM COMPONENTS 1999-2022

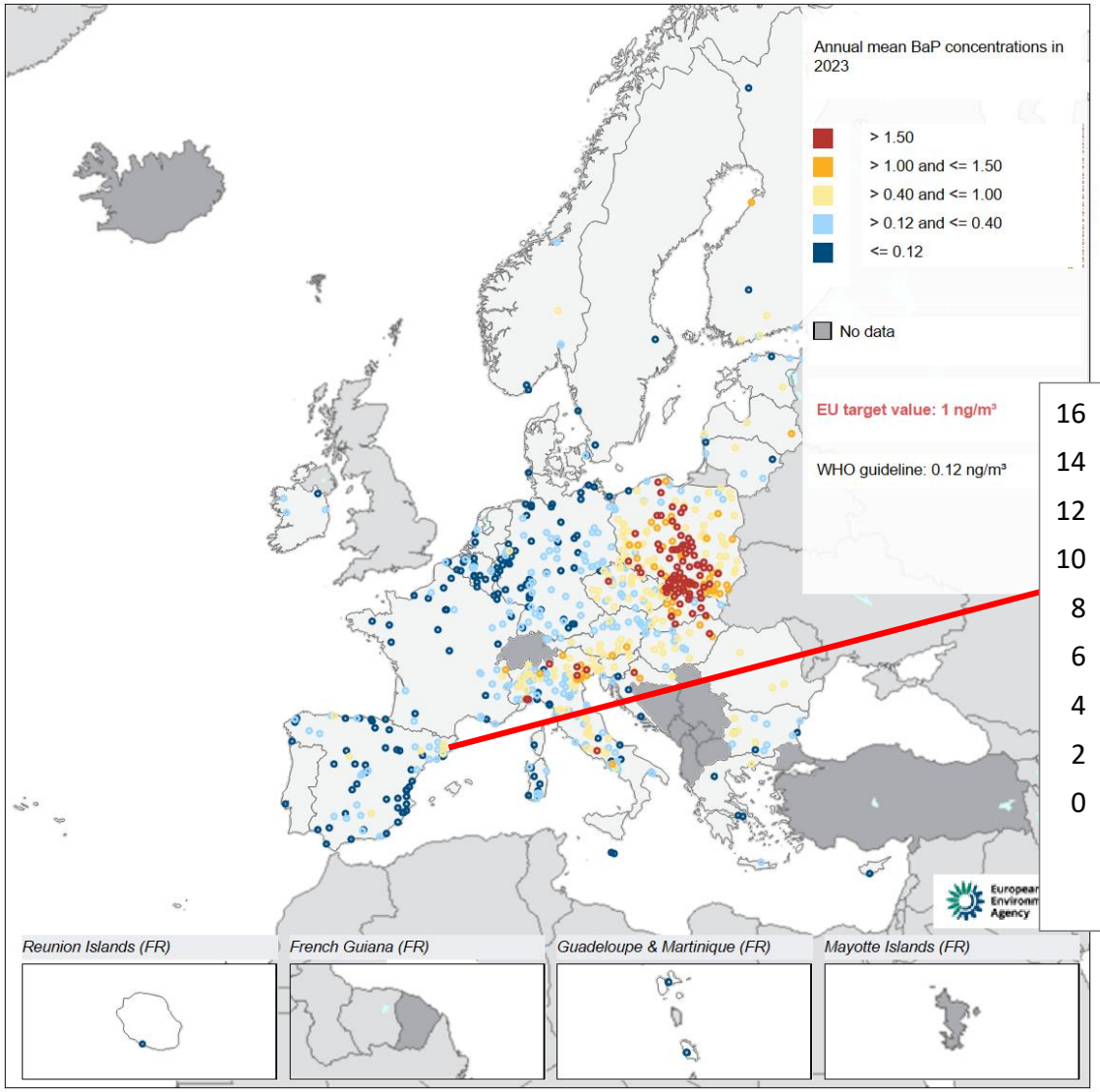


ORGANIC PM POLLUTANTS SHOULD GUIDE ON HOW REDUCE SOA & PM2.5



The problem of Benzo-a-pirene

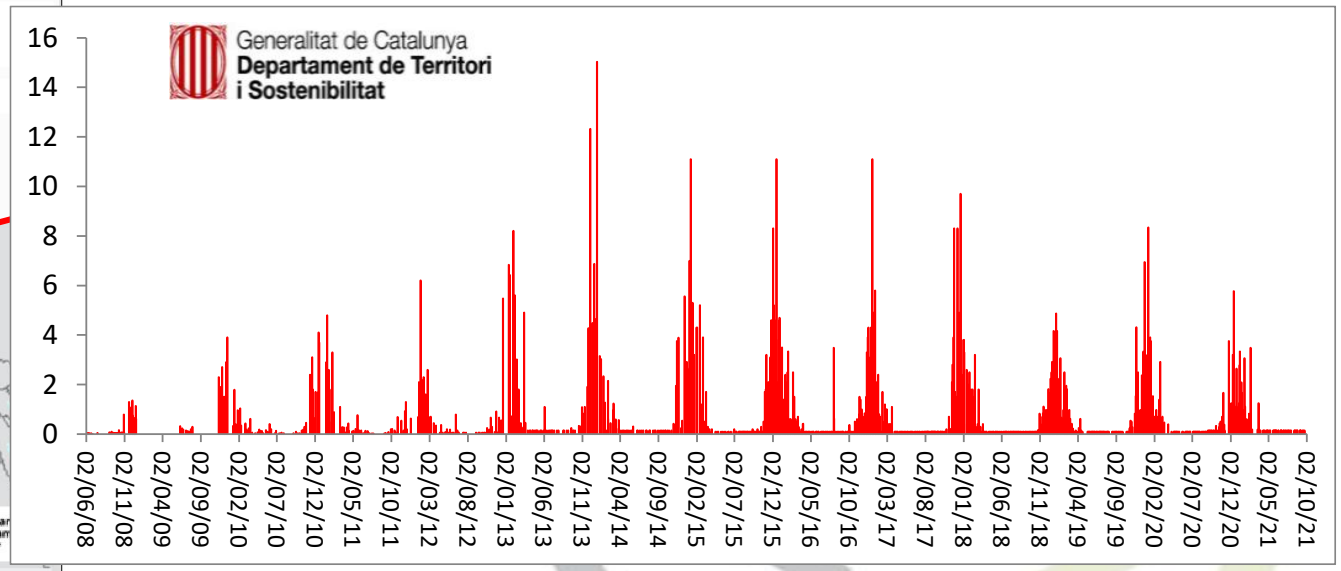
https://www.eea.europa.eu/publications/europes-air-quality-status-2025



BaP,
annual target value 2023

European Environment Agency

Manlleu BaP



CSIC

idaea

The problem of ozone

http://www.geo.sunysb.edu/ess-workshops/lesson-plans.html

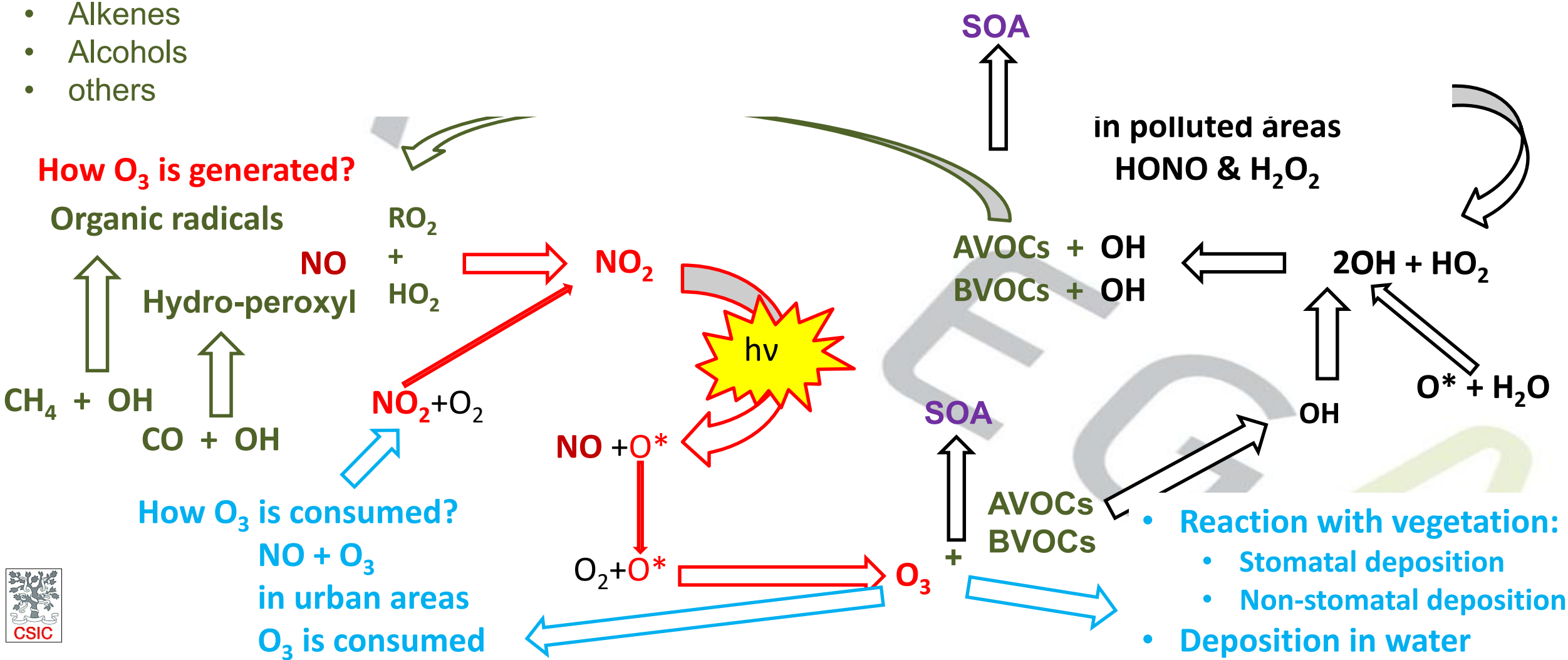
The problem of ozone

Relevant VOCs to generate O_3

- PAHs
- Aldehydes & ketones
- A few alkanes
- Alkenes
- Alcohols
- others

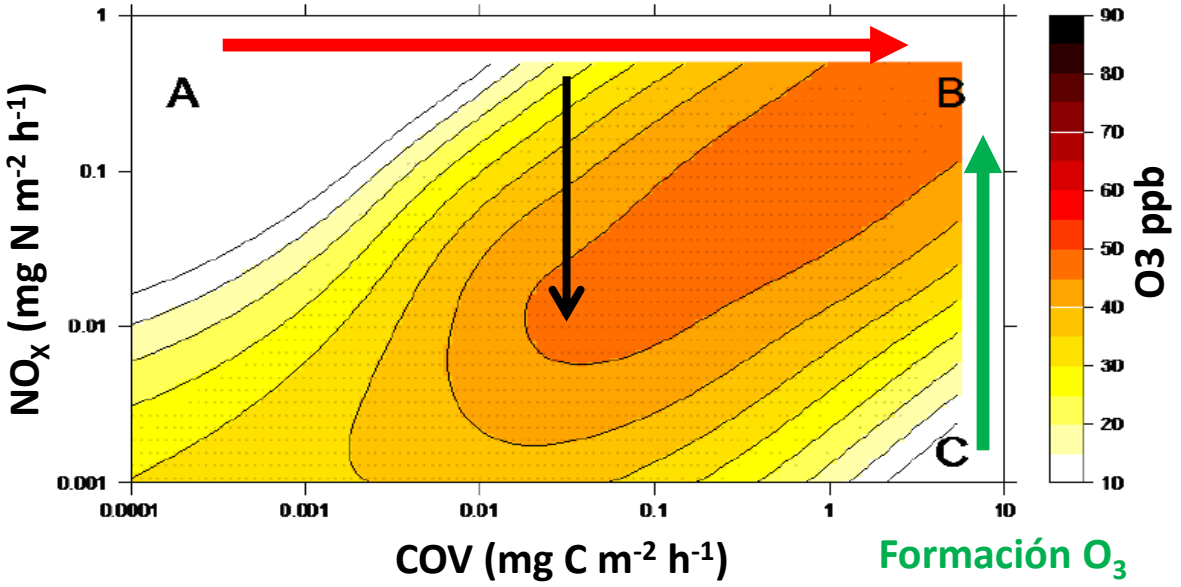
Lifetime in the atmosphere

- Isoprene 1h
- Methane 10 years

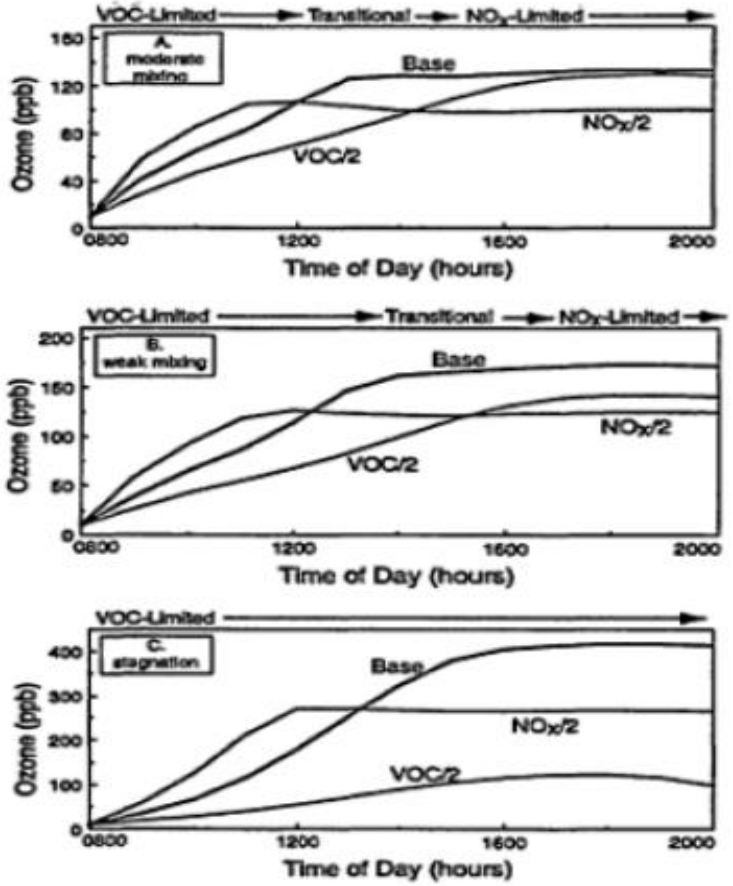


The problem of ozone

Formación O_3 limitada por COVs (radicales OH<NO_X) sobretodo ciudades

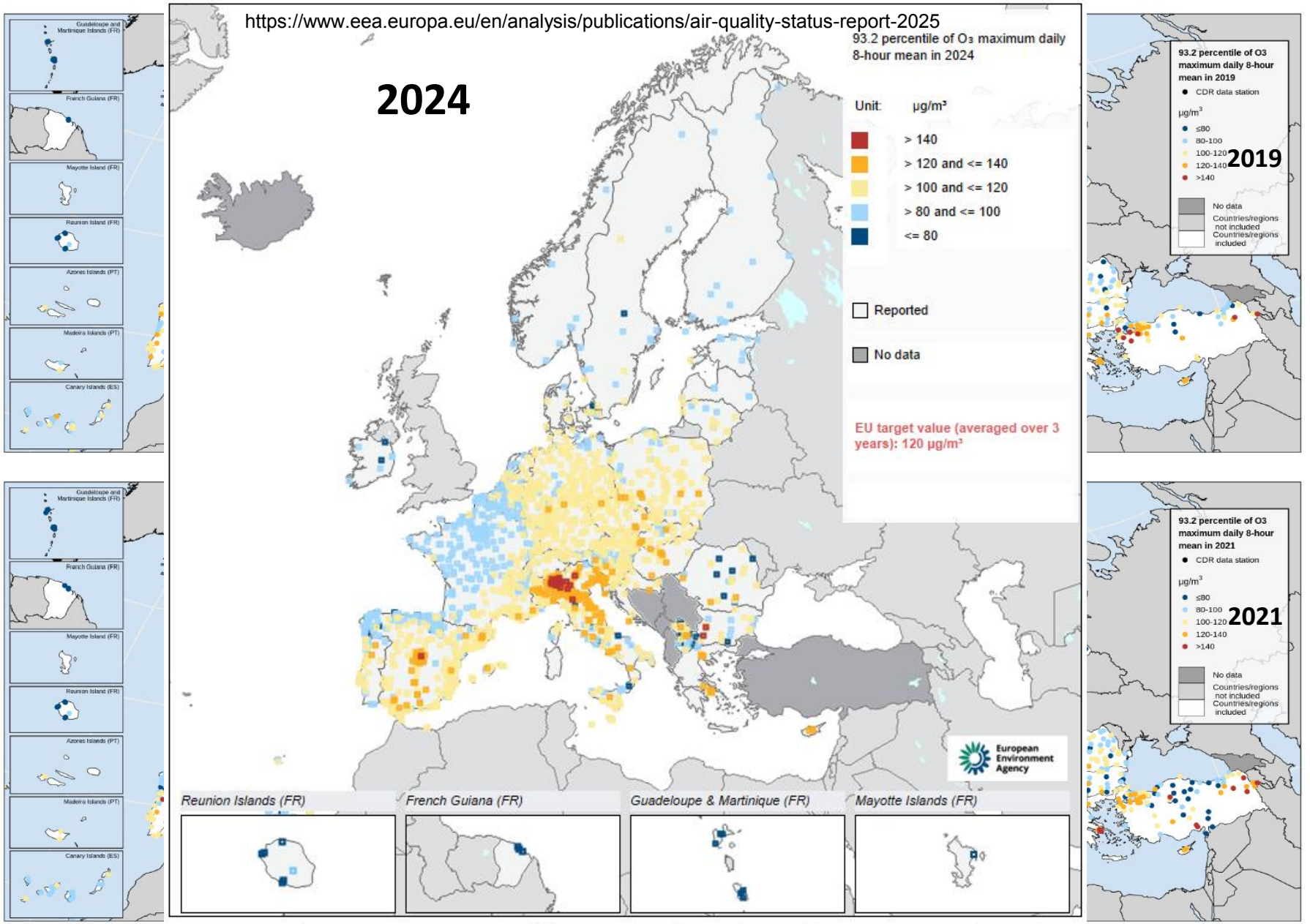


Formación O_3 limitada por NO_X (radicales OH>NO_X) sobretodo rural



Monks et al., 2015, ACP

The problem of ozone



O_3, 93.2 percentile 8hDM

9th April 2025

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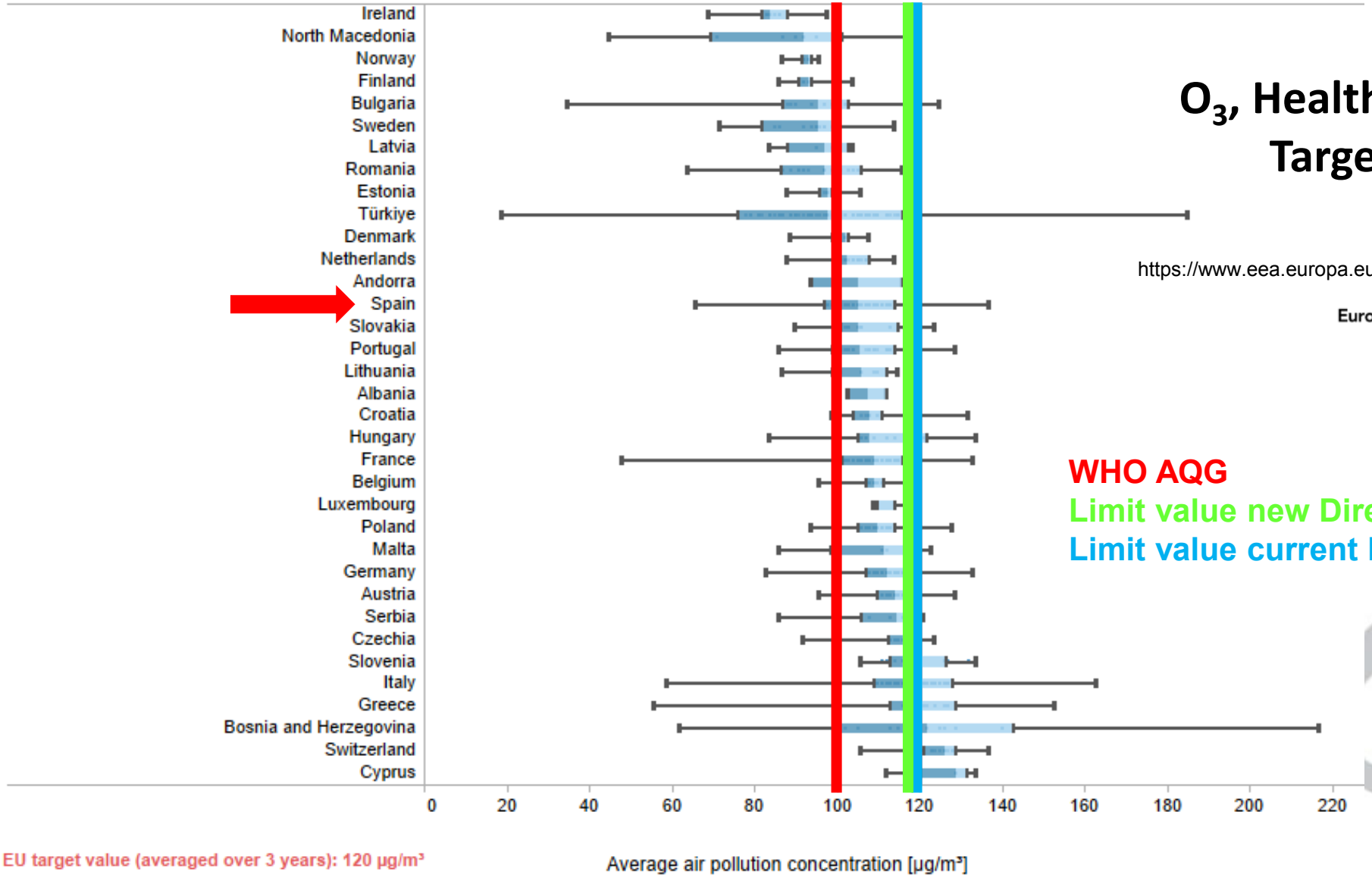
The problem of ozone



O_3, Health Protection 2023 Target Value

https://www.eea.europa.eu/en/analysis/publications/air-quality-status-report-2025

European Environment Agency

9th April 2025

WHO AQG

Limit value new Directive >120 MD8h <3d/y

Limit value current EU AQ Directive >120 MD8h<25 d/y

THANKS!

IR0000032 – ITINERIS, Italian Integrated Environmental Research Infrastructures System
(D.D. n. 130/2022 - CUP B53C22002150006) Funded by EU - Next Generation EU PNRR-Mission 4 “Education and Research” - Component 2: “From research to business” - Investment 3.1: “Fund for the realisation of an integrated system of research and innovation infrastructures”

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