ICP Materials

Progress on work plan 2024-2025

2024 EMEP/ WGE EB meeting (Hybrid)
28th February 2024

2024-2025 workplan for the implementation of the Convention

- 1.1.1.9 Monitor and assess impact on environment of corrosion and soiling effects on materials and their trends
  - Report on dose-response functions for trend materials (2024) Ongoing work
  - Technical manual for 2024–2025 exposure for trend analysis (2025)
- 1.1.1.10 Policy-relevant user-friendly indicators (UNESCO sites)
  - Risk assessment for selected monuments based on retrospective trends in 2000, 2010 and 2020 and EMEP 01° x 01° data (2024) Ongoing work – Status report
  - Cost assessment for selected monuments based on retrospective trends in 2000, 2010 and 2020 and EMEP 01° x 01° data (2025)

40th meeting
May 6-8, 2024

Welcome to Madrid and the National Center for Metallurgical Research (CENIM)!

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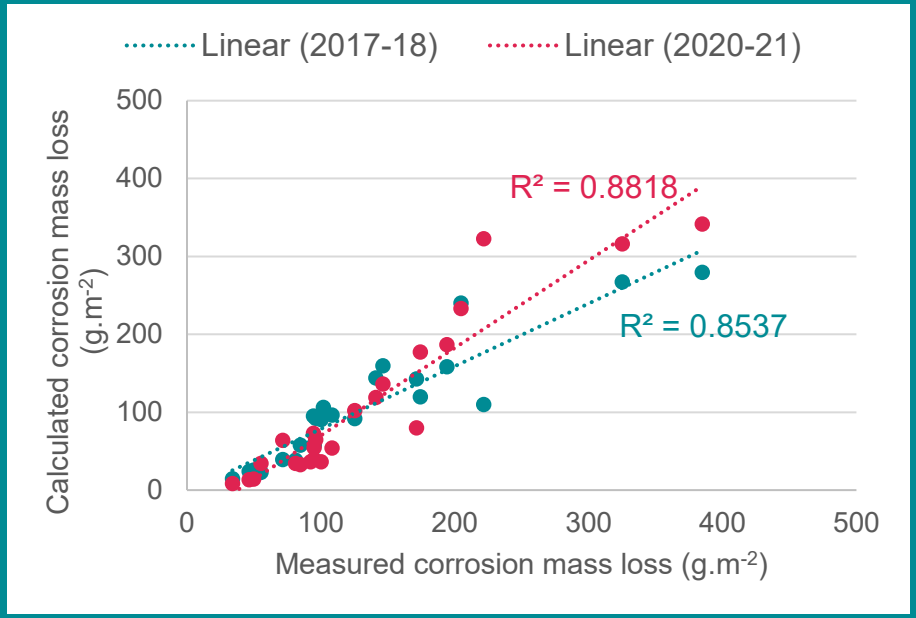
Coupling to Climate Change

- Dose-response functions:
  - Quantitative evaluation of corrosion or soiling by relating atmospheric pollution and climate parameters through historical data from the programme.
- Corrosion sensors (*Super-sites*):
  - Time-resolved sensors that monitor corrosion. Possibly sensitive to local weather events such as increased precipitation.

https://nke-instrumentation.com/produit/aircorr-corrosion/

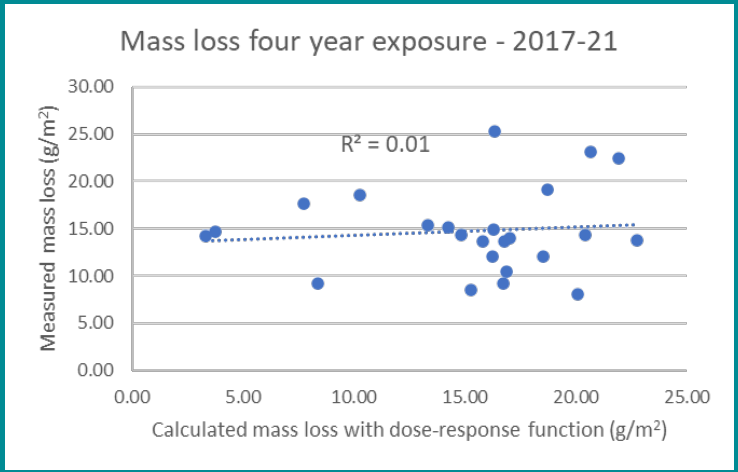
Ongoing work 2024: Dose-response functions



– Carbon steel dose-response function remains relevant.

Ongoing work 2024: Dose-response functions

- Updating the Dose-response functions of Zinc and Limestone materials.



Latest 4-year trend exposure of Zinc indicates the need of updating the multi-pollutant dose-response function.

Ongoing 2024: New Trend Exposure

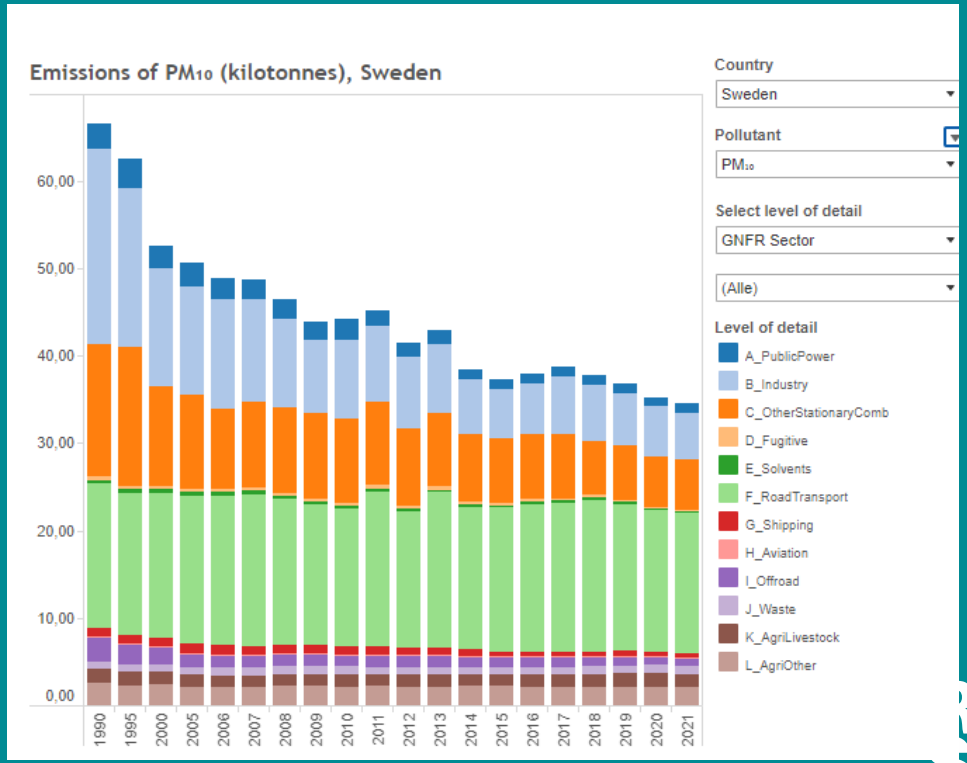
- Technical manual for 2024–2025 exposure for trend analysis (2025).
- A new exposure will start on October 2024 for trend materials and other selected materials.

Ideas for 2026-2027

- Focus on Particulate Matter:
  - Influence of PM on the corrosion and soiling of materials.
  - Recently, a relationship has been observed regarding the effects of PM on materials.
  - Measured PM concentrations in our test sites have not decreased.
  - *Coupling to health effects (synergies with Joint Task Force on Health Aspects of Air Pollution)*

Focus on PM effects on Materials

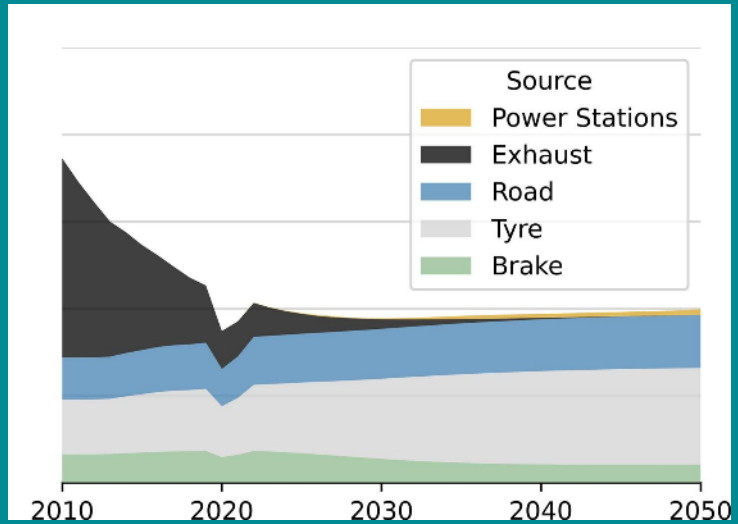
- Influence of particulate matter on the atmospheric corrosion of building and heritage materials.
  - Review of relevant sources of particulate matter.
  - Review of susceptible alloys



EMEP CEIP - Data viewer – reported emissions data

Focus on PM effects on Materials

- Non-exhaust emissions from mobile sources: Significant contributions to total PM emissions in Europe
  - Review of emission inventories.
- Focus on PM emissions by the transport sector:
  - Future trends?
  - Coupling to Health Effects?

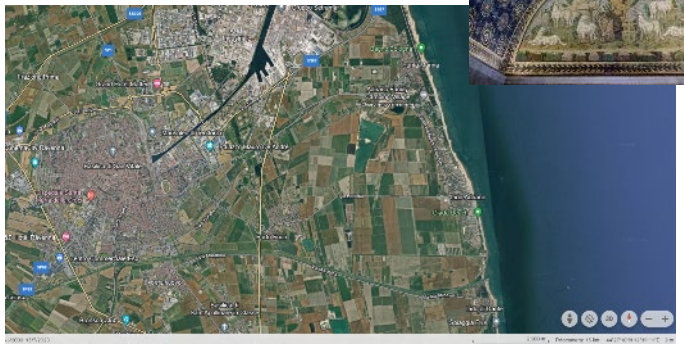


"$PM_{2.5}$ emissions from vehicle and power stations from 2010 to 2050" Daniel Mehlig, Iain Staffell, Marc Stettler, Helen ApSimon, "Accelerating electric vehicle uptake favours greenhouse gas over air pollutant emissions", Transportation Research Part D: Transport and Environment, Volume 124, 2023, 103954, ISSN 1361-9209, https://doi.org/10.1016/j.trd.2023.103954.

“Besides its impacts on biodiversity and natural heritage, climate change also affects the world’s cultural heritage, eroding archaeological remains and historical buildings both on land and underwater” as reported in a publication “Changing minds, not the climate!” (UNESCO 2019,b),

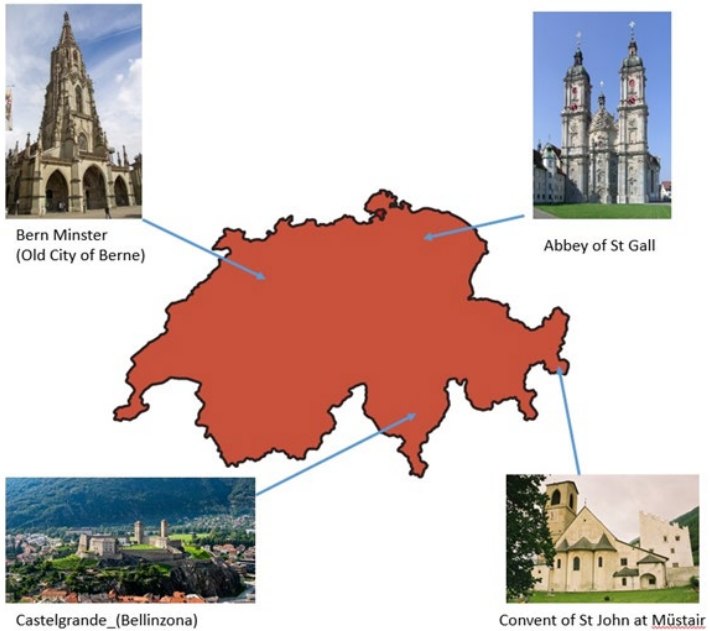
Higher temperatures, increased precipitation, drought, fire, floods, avalanches, glacial lake outbursts, rising sea levels and the increased frequency of extreme weather events threaten several Heritage Sites and the economies and communities that depend on tourism.

According to UNESCO, more than one-third of World Heritage cities are located in coastal areas threatened by rising sea levels (UNESCO 2021 https://whc.unesco.org/en/events/1633/). Venice and its Lagoon is an evident example.



Last year, Ravenna, where eight UNESCO Monuments are present, was threatened by an important extreme weather event. It was necessary to flood the surrounding fields to prevent Ravenna and its mosaics from ending up under water, destroying agricultural products.

Part VII (2023): Application of models with increased resolution in the study of damage at selected UNESCO sites – Switzerland [Report N. 96]



Application of air quality models with increased resolution at selected UNESCO sites in Switzerland to assess the damage on materials due to air pollution

EMEP01 with resolution 01°x 01°long-lat (9x11 km at 40°N)
Swiss national models with higher resolutions 100x100m ÷ 1000x1000m

Old City of Berne, Abbey of St Gall, Benedictine Convent of St John at Müstair and Three Castles, Defensive Wall and Ramparts of the Market-Town of Bellinzona.

Limestone Recession rate, µm

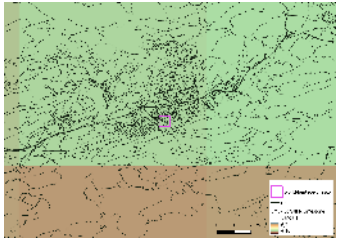
range for R: (4.16÷6.7) µm

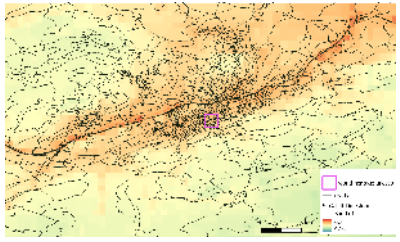
Air pollutant concentrations are not elevated for the selected Swiss UNESCO sites investigated:

- the recession rates modelled with national input maps are higher than those based on EMEP01 maps (around 20%).
- the recession values are below 2050 target (6.4 µm year^{-1})
- the colour red/ orange highlights the places with high buildings density and with traffic roads
- number of years to reach 30% loss of reflectance is above or very close to 2050 target of 15 years before action.
- *the major outcome of this study is that using a model with a resolution at urban scale can result in a more realistic estimation of the effect of air pollutants on cultural objects.*

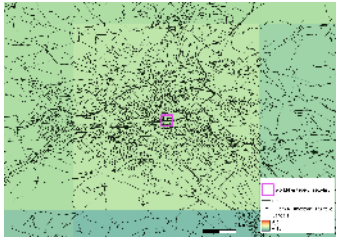
EMEP 01° x 01°

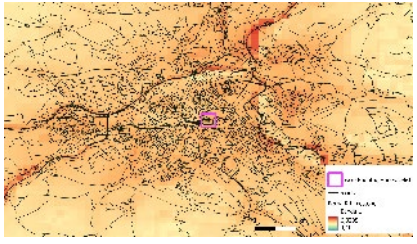
SWISS 100m x 100m (aligned)



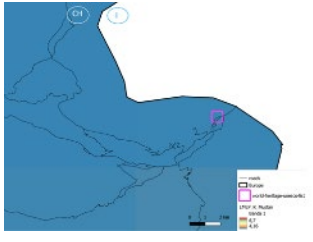


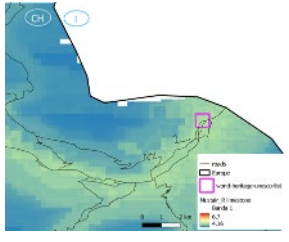
St Gall
E: 4.8; S: 5.8



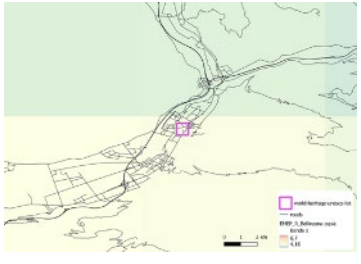


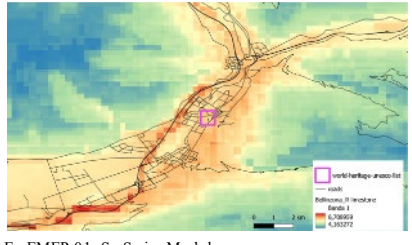
Bern
E: 4.9; S: 5.7





Müstair
E: 4.2; S: 4.8





Bellinzona
E: 4.7; S: 5.8

E= EMEP 01; S= Swiss Model

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Part VIII (2024): Risk assessment. Retrospective trends in 2000, 2010 and 2020 EMEP 01°x01° data [work in progress]

Name of the cultural object	Total surface (m^2)	Limestone marble (m^2)	Sandstone (m^2)	Render, mortar, plaster (m^2)	Brick (m^2)	Glass (m^2)	Copper (m^2)	Bronze (m^2)	Other
Cathedral of Saint Domnius	1 960	1 385	0	42.99	492.08	13	-	Yes	Wood, steel
Aachen Cathedral	17 300	3 287	7 698	-	17	1 557	-	Yes	Greywacke, trachyte, tuff, granite, lead, slate
Speyer Cathedral	26 000		16 900	-	-	1 040	7 800	Yes	Slate
Würzburg Residence	41 100	1 027	19 522	5 959	-	3 493	-	-	Painted surfaces, slate
Porta Nigra	5 500		4 840	-	-	-	660	-	-
Town Hall of Bremen	4 060		1 868	41	690	244	1 218	-	Painted surfaces,
Wartburg Castle (palace and keep)	4 300	201	2 165	-	-	120	765	-	Wartburg-Konglomerat
Hercules Monument	15 100	-	0	-	-	-	151	-	Tuff
The Gatehouse of Lorsch Abbey	570	17	120	200	-	Yes	-	-	Slate
The Colosseum	22 750	19 450	-	-	Yes	-	-	-	Roman concrete, tuff
The Tower of Pisa	7 735	7 735	-	-	-	-	-	Yes	-
Palazzo Madama	7 300	2 700	-	900	3 500	200	-	-	Gneiss, terracotta tiles
Ghirlandina Tower	2 650	2 623	27	-	-	-	-	Yes	Trackyte, lead
Royal Palace of Caserta	149 800	54 700	-	4 000	28 500	17 400	-	-	Steel, terracotta tiles, wood
Hydroparken	40 460	-	-	11 220	1 460	2 820	-	-	Painted surfaces, Tar paper/ruberoid, concrete
Nidarosdomen	4 430	60	60	-	-	94	1 165	Yes	Talc-schist, slate
Drottningholm Palace Theatre	4 205	-	55	1 577	-	288	-	-	Painted surfaces, wood
Nederluleå church	3 166	-	-	2 603	-	175	2	Yes	Painted surfaces, wood, tarred shingles
Wall of the Hanseatic Town of Visby	62 000	58 900	-	3 100	-	-	-	-	-
Towers of the cathedral of the Abbey of St. Gall	3 150	158	2 918	-	-	-	75	Yes	-
Bern Minster	8 980	240	8 740	Yes	-	Yes	-	Yes	Lead

Table Report N. 83 Occurrence of materials in the twenty-one cultural objects

Call for data

Twenty-one unique monuments that are part of UNESCO world cultural heritage list.

Six Countries: Croatia, Germany, Italy, Norway, Sweden, Switzerland

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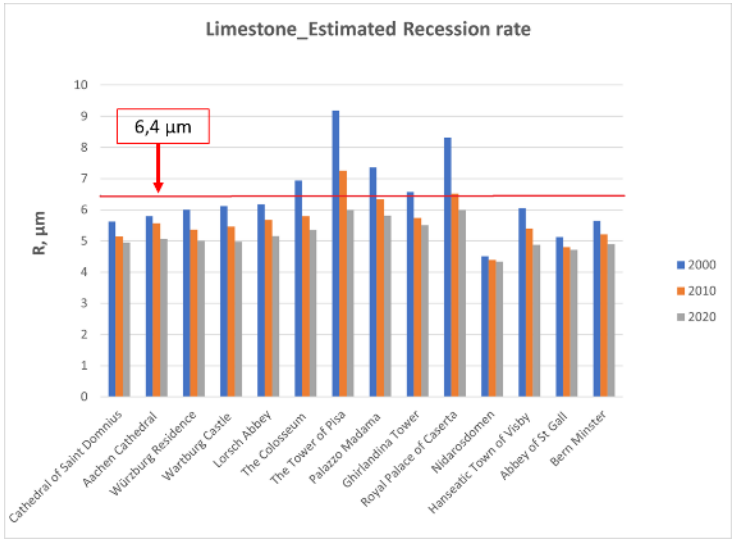
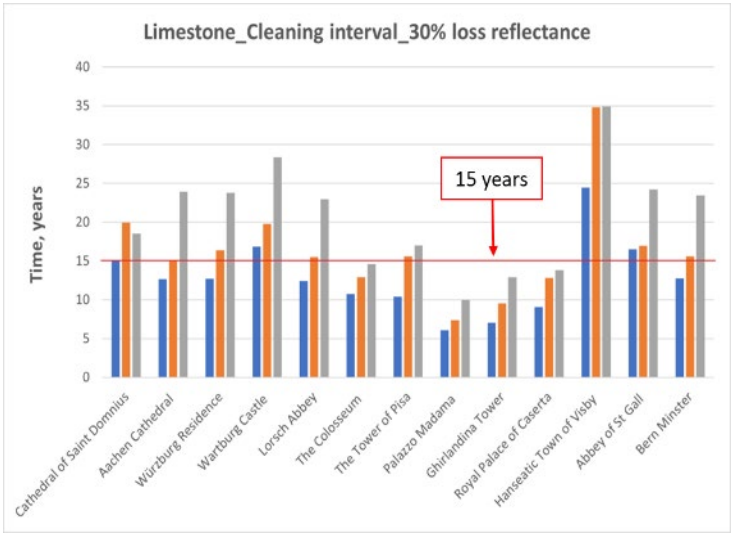
LIMESTONE





$R = 4.0 + 0.0059[SO2]Rh60 + 0.054Rain[H+] + 0.078[HNO3]Rh60 + 0.0258PM10$

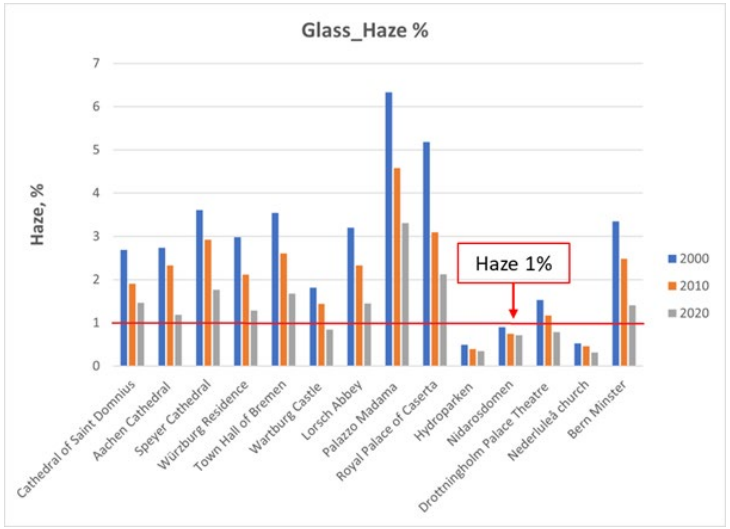
$\Delta R/Ro = 1 - \exp(-PM10 \times t \times 4.3 \times 10\text{-}6)$

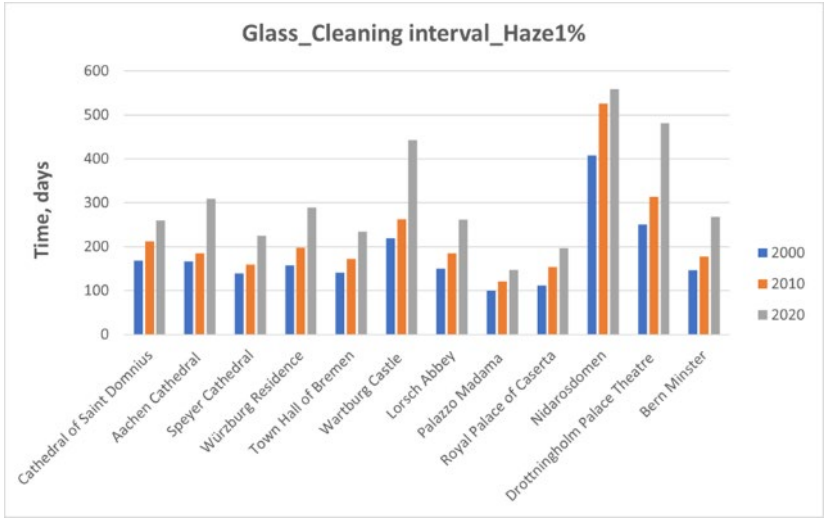
Year 2020: R values below 2050 target (6.4 µm year^{-1}) for all monuments

Number of years to reach 30% loss of reflectance increases but for some monuments is far from 2050 target (15 years) even for the year 2020

*Dose-response function of limestone is currently on revision.

GLASS





$$\text{Haze} = (0.2529 \cdot [SO2] + 0.1080 \cdot [NO2] + 0.1473 \cdot [PM10]) \cdot 1/(1 + (382/t)1.86$$

With the exception of the monuments located in North Europe Countries, the calculated values for haze are higher than 1% a one-year exposure, even for the year 2020

Plain text for minutes

1. The Co-chairs of ICP Materials reported on developments and the outcomes of the progress of activities including an update on the upcoming trend exposure and status on the case studies on UNESCO cultural heritage sites. All work plan items 2024-2025 are on track.

2. The latest four-year trend exposure of zinc indicates the need of updating its dose-response function in the multi-pollutant situation. A new trend exposure is planned to begin in October 2024, with both trend materials and other selected materials. Particulate Matter is proposed to be the upcoming focus for the work regarding its effects on the corrosion and soiling of materials. Synergies with other ICPs (ex. Health) would benefit the work.

3. The recession rates for UNESCO sites modelled with national input maps are higher than those based on EMEP01 maps (around 20%). The major outcome of this study is that using a model with a resolution at urban scale can result in a more realistic estimation of the effect of air pollutants on cultural object.