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Executive Body for the Convention on Long-range Transboundary Air Pollution

Steering Body to the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe

Working Group on Effects

Sixth joint session
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Item 3 of the provisional agenda
Progress in activities in 2020 and further development of effects-oriented activities
Item 12 of the provisional agenda
Progress in activities of the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe in 2020 and future work

2020 Joint progress report on policy-relevant scientific findings*

Note prepared by the Chairs of the Steering Body to the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe and the Working Group on Effects, in cooperation with the secretariat

Summary

The present report was drafted by the Extended Bureau of the Working Group on Effects[a] and the Extended Bureau of the Steering Body to the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe[b] in cooperation with the secretariat to the Convention on Long-range Transboundary Air Pollution. The review of recent scientific findings is based on the information provided by the lead countries and the programme centres of the international cooperative programmes, and is submitted in accordance with the 2020–2021 workplan for the implementation of the Convention (ECE/EB.AIR/144/Add.2).

[a] *Comprising the Bureau of the Working Group; the Chairs of the International Cooperative Programme (ICP) task forces, the Joint Task Force on the Health Effects of Air Pollution; and representatives of the ICP programme centres.*

* This document was scheduled for publication after the standard publication date owing to circumstances beyond the submitter's control.

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[b] *Comprising the Bureau of the Steering Body, the Chairs of the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP) task forces and representatives of EMEP centres.*

I. Introduction

1. The present report was compiled by the Chairs of the Steering Body to the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP) and the Working Group on Effects, in accordance with the 2020–2021 workplan for the implementation of the Convention on Long-range Transboundary Air Pollution (ECE/EB.AIR/144/Add.2). The report reflects achievements during 2019 and 2020 and was prepared with support from the scientific subsidiary bodies. The report is the sixth common report on the work under the EMEP Steering Body and the Working Group on Effects, reflecting the new organization of the two bodies with joint, integrated sessions based on a common agenda. These joint reports represent a further integration of the scientific work under the Convention and should be seen as strengthening the scientific basis for the Convention's policy development.

II. Air pollution effects on health

2. The twenty-third meeting of the Joint Task Force on the Health Aspects of Air Pollution was held online on 12 and 13 May 2020. Thirty-six representatives from 33 Parties to the Convention, 10 temporary advisers and 14 observers attended the meeting. The European Union – a Party to the Convention – was represented by the European Commission and the European Environment Agency. The meeting discussed national and international policies and processes on air quality and health, with contributions from the United Nations Economic Commission for Europe (ECE) secretariat, the European Commission and the World Health Organization (WHO) headquarters. The updates on country experiences and capacity-building activities highlighted the WHO training workshop on air quality and health – strengthening capacities in assessing health risks of air pollution for the experts from Armenia, Azerbaijan and Georgia (Tbilisi, 12–15 November 2019), organized in cooperation with the secretariat and the European Environment Agency. In terms of tools on air quality and health, the AirQ+ model (version two) was presented, as well as the development of the German-language version. Progress in research was reported, including on the effects of low-level air pollution (in a major new study in Europe), ambient ultrafine particles, source apportionment in PM, co-benefits of climate change mitigation of black carbon on air quality and health and the United States Environmental Protection Agency integrated science assessment on ozone. An outlook for global air quality and relevant policy interventions was presented, as well as reflection on approaches to quantifying health impacts of air pollutants after the Health risks of air pollution in Europe project.[1] Information was provided on the ongoing update of the WHO global air quality guidelines, as well as on new initiatives, such as estimation of morbidity from air pollution and its economic costs. The Working Group on Polycyclic Aromatic Hydrocarbons gave an update on the progress of the technical report. To address current concerns, an overview of the emerging evidence on linkages between coronavirus disease (COVID-19) and air pollution was given, as well as of relevant WHO activities and the effects of lockdown measures on air pollutants concentrations. Communication and public health messages featured in presentations on the European Green Deal and on risk communication and personal level interventions to reduce exposure and minimize health effects of air pollution. An interactive presentation was given on good practice in communicating public health messages. The meeting concluded with an overview of progress in implementing the Task Force 2020–2021 workplan.

[1] World Health Organization (WHO) Regional Office for Europe, Health risks of air pollution in Europe – HRAPIE project. Recommendations for concentration–response functions for cost–benefit analysis of particulate matter, ozone and nitrogen dioxide (Copenhagen, 2013). Available at: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwitnuv14rjqAhUCWBoKHcLvD3gQFjABegQIBRAC&url=https%3A%2F%2Fwww.euro.who.int%2F__data%2Fassets%2Fpdf_file%2F0006%2F238956%2FHealth_risks_air_pollution_HRAPIE_project.pdf%3Fua%3D238951&usg=AOvVaw2IOBCe43MgTwNG6useUP5N.

III. Air pollution effects on materials

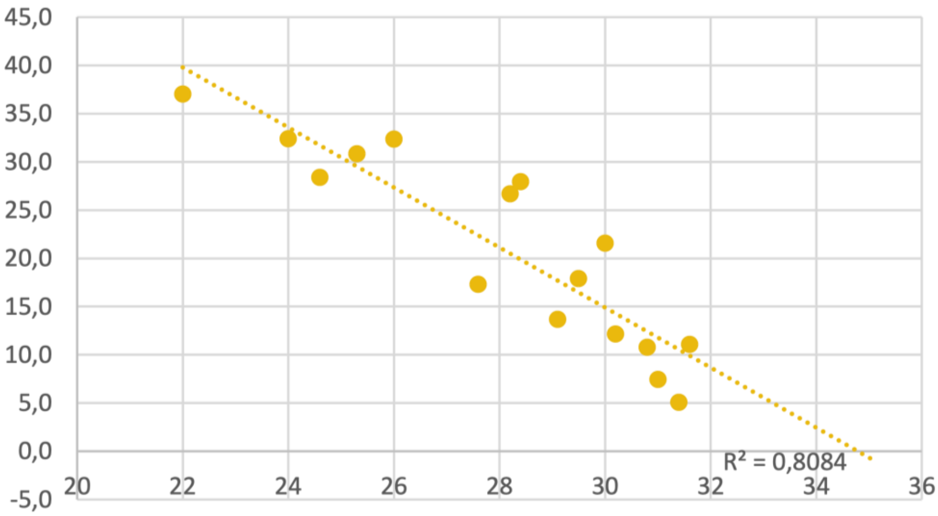
3. The International Cooperative Programme on Effects of Air Pollution on Materials, including Historic and Cultural Monuments (ICP Materials) conducts repeated exposures for trend analysis every third year and the latest exposure concluded in 2018. All data on environment, corrosion and soiling produced so far is given in the corresponding ICP Materials reports, which are available as PDF files for download at the ICP Materials home page.[2]

4. First results from exposure of coil-coated materials – a material that is a new addition to the programme – show a good correlation between environmental parameters (PM_{10}) and gloss (see figure below), which is promising for future development of dose-response functions for soiling of non-transparent materials.

5. These results, together with those of the other materials (carbon steel, stainless steel, weathering steel, zinc, copper, limestone and soiling samples of modern glass, limestone and marble) will be included in a report on trends in pollution, corrosion and soiling covering data from the first exposure in 1987 to the most recent data. In 2020, the fourth report covering the call for data on United Nations Educational, Scientific and Cultural Organization (UNESCO) world cultural heritage sites will also be presented. It will include the relative importance of individual pollutants and the effect of their reduction on the damage cost for selected UNESCO sites.

Correlation of PM_{10} vs Gloss of white coil-coated samples exposed for one year in the ICP Materials network of test sites

PM_{10}/µg m^{-3}



IV. Air pollution effects on terrestrial ecosystems

A. Forests

6. The International Cooperative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests) monitors the response of forests to air pollution and other abiotic and biotic stressors on 5,852 level I plots (as at 2019) and on 623 level II plots (as at 2018). A total of 58 scientific papers based on ICP Forests data/plot infrastructure were published in international peer-reviewed journals in 2019.

7. Particular attention was given to atmospheric deposition. Within the ICP Forests programme, deposition monitoring has been running continuously since 1997 in 64

[2] See www.corr-institute.se/icp-materials.

permanent level II plots. During this period, the implementation of the protocols of the Convention and economic transformation led to a marked decrease of sulphur dioxide (SO_2) emission in Europe (European Environment Agency, 2016).[3] As a consequence, sea salt corrected sulphate throughfall deposition dramatically decreased in the considered period, reaching values as low as 30 per cent of those found in the late 1990s, and causing a similar decrease of deposition acidity. In the case of nitrogen compounds, the average reduction in throughfall deposition was also present, but was much less marked. Note that total deposition of nitrogen typically is a factor 1 to 2 higher than throughfall deposition, due to canopy exchange processes.

8. The spatial distribution of yearly throughfall deposition of nitrate and ammonium collected in 259 ICP Forests level II plots across Europe in 2018 shows a marked spatial variability of atmospheric deposition due to the uneven distribution of emission sources and receptors and the complex orography of a part of Europe. However, on a broader scale, regional patterns in throughfall deposition arise. In the case of nitrate, high (> 8 kg of nitrate – as nitrogen per hectare per year (NO_3--N ha^{-1} yr^{-1}) and medium (4–8 kg NO_3--N ha^{-1} yr^{-1}) throughfall deposition were mainly found in Central Europe, including Austria, Belgium, Czechia, Germany, Poland and Slovenia. The Central European area of high (>8 kg NH_4+-N ha^{-1} yr^{-1}) and medium (>4–8 kg of ammonium – as nitrogen per hectare per year (NH_4+-N ha^{-1} yr^{-1}) ammonium throughfall deposition is larger than for nitrate, with higher throughfall deposition values, particularly in southern Germany, northern Italy, western Slovakia and Poland. The area with medium (>4–8 kg SO_4(2-)- as sulphur (S) per hectare per year (ha^{-1} yr^{-1})) and high (>8 kg SO_4(2-)-S ha^{-1} yr^{-1}) throughfall deposition of sulphate is smaller than for nitrogen compounds: it includes Belgium, Italy, Slovenia and an area between Czechia, Germany, Poland and Slovakia. Further plots with high sulphate throughfall deposition were found in the proximity of large point sources and harbours in Austria, France, Greece and Spain.

9. Nutrient levels in tree foliage reflect atmospheric and soil-related influences. Foliar nutrient analyses have been undertaken at least once on 1,061 level II intensive forest monitoring sites in 31 countries since the 1990s. The data analysis revealed that foliar N and foliar P concentrations have decreased significantly at ICP Forests monitoring sites over the past two decades for both broadleaf and coniferous trees. The rate of decrease in foliar phosphorus (P) is more than double that for foliar N, resulting in a shift towards higher N:P ratios. Shifts in the ratio between levels of foliar N and foliar P can be attributed to human emissions of N and carbon. The resulting nutrient imbalance has the potential to limit tree growth, leading to a reduction in wood supply and carbon sequestration by forests, and to decrease the resistance and resilience of forest trees to stressors such as drought or insect infestations. The implications for forest productivity and for the potential of forest ecosystems to respond to global environmental change underline the importance of monitoring the deposition of N and other elements into forests and their subsequent impacts on the structure and functioning of forest ecosystems. Counteracting nutrient imbalances in forest trees through P fertilization of forest soils is not generally considered viable or cost-effective in forests.

B. Forested catchments

1. Heavy metals

10. Emission of cadmium (Cd), lead (Pb) and mercury (Hg) to the atmosphere is through natural and anthropogenic sources, such as energy production, waste incineration and various use of metals. The emission of anthropogenic Cd, Pb and Hg has increased since the start of the industrial era. Emission controls have resulted in a decline in heavy metal emission and deposition during recent decades. In Europe, emission of Cd peaked in the 1960s and that of Pb peaked in the 1970s. Declining metal deposition and/or recovery from acidification during

[3] National emissions reported to the Convention on Long-range Transboundary Air Pollution (LRTAP Convention). Available at https://www.eea.europa.eu/data-and-maps/data/national-emissions-reported-to-the-convention-on-long-range-transboundary-air-pollution-lrtap-convention-10.

recent decades have resulted in decreasing temporal trends of Cd and Pb concentrations in runoff in many of the International Cooperative Programme on Integrated Monitoring of Air Pollution Effects on Ecosystems (ICP Integrated Monitoring) European sites during the last 30 years.[4] The concentrations of Hg in runoff did not show any significant trend. Decreasing trends of Cd and Pb were detected in previous studies, but the data from ICP Integrated Monitoring are unique in the sense that they are both widespread and long-term. Catchment budgets of Cd and Pb indicated that releases to runoff water of these metals accounted for only 13–70 per cent and 21–56 per cent, respectively, of the throughfall and litter fall input. These results agree with earlier catchment budgets for metals, indicating that metals are accumulating in catchment soils.

2. Nitrogen impacts

11. Widespread scientific research, long-term monitoring and integrated assessment modelling have formed the basis for the policy agreements under the Convention, leading to substantial reductions in air pollution emissions and decreased ecosystem impacts.[5] Results of the ICP Integrated Monitoring network confirm the positive effects of the continuing emission reductions in Europe. ICP Integrated Monitoring sites showed dominantly negative trend slopes of total inorganic nitrogen (TIN) in concentrations and bulk/wet deposition between 1990 and 2017 (95 per cent and 91 per cent of the sites, respectively).[6] Decrease of nitrate and ammonium in concentrations was significant at 91 per cent and 77 per cent of the sites, and in fluxes at 64 per cent and 59 per cent of the sites, respectively. Long-term trends in precipitation amounts in 1990–2017 showed dominantly increasing trend slopes (68 per cent of the sites), but trends were rarely significant. The short- and long-term variations in precipitation may mask long-term trends caused by N deposition. TIN concentrations in throughfall deposition also showed predominantly decreasing trend slopes (81 per cent of the sites) and decrease in nitrate and ammonium concentrations was significant at 62 per cent and 54 per cent of the sites, respectively. Deposition of TIN in throughfall decreased at 81 per cent of the sites, and the decrease in nitrate and ammonium fluxes was significant at 69 per cent and 46 per cent of the sites, respectively. Only a few sites showed significant increases in inorganic nitrogen concentrations and fluxes in throughfall.

12. ICP Integrated Monitoring catchments have increasingly responded to the decreases in the emission and deposition of nitrogen in Europe.[3] Concentrations and fluxes of TIN in runoff water exhibited dominantly downward trend slopes (76 per cent and 69 per cent of the sites, respectively). Decrease of nitrate and ammonium in concentrations was significant at 59 per cent and 36 per cent of the sites, and but the decrease in fluxes was significant only at 25 per cent and 31 per cent of the sites, respectively. A significant negative correlation was found between the annual change of TIN concentrations and fluxes in runoff, and mean TIN fluxes in throughfall, total N concentrations and N/P-ratios in foliage and litterfall, and total N concentrations and fluxes in soil water. The results also showed that the most N-affected sites with the highest N deposition to the forest floor and highest N concentrations in foliage, litterfall, runoff water and soil water, showed the most pronounced decreases of TIN in runoff.

13. It can thus be concluded that long-term monitoring and research sites are reference systems for detecting long-term impacts and developing and validating ecological models. The results also indicated that complex ecosystem processes regulate the impacts,

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[4] Karin Eklöf and others, “Temporal trends and input-output budgets of heavy metals in ICP IM catchments” in Sirpa Kleemola and Martin Forsius, eds., Twenty-ninth Annual Report 2020: Convention on Long-range Transboundary Air Pollution Convention, ICP on Integrated Monitoring of Air Pollution Effects on Ecosystems, Reports of the Finnish Environment Institute, pp. 29–34.

[5] Peringe Grennfelt and others, “Acid rain and air pollution – 50 years of progress in environmental science and policy”, Ambio, vol. 49 (2020), pp. 849–864.

[6] Jussi Vuorenmaa and others, “Long-term changes in the inorganic nitrogen output in European ICP Integrated Monitoring catchments – an assessment of the impact of internal nitrogen-related parameters and exceedances of critical loads of eutrophication” in Kleemola and Forsius, eds., Twenty-ninth Annual Report 2020: Convention on Long-range Transboundary Air Pollution Convention, ICP on Integrated Monitoring of Air Pollution Effects on Ecosystems, Reports of the Finnish Environment Institute, pp. 35–45.

accumulation and release of N compounds and heavy metals, indicating the need for continued long-term measurements in different ecosystem compartments.

V. Air pollution effects on aquatic ecosystems

14. The recently published report on trends in recovery from acidification demonstrated substantial recovery from acidification, looking at trajectories of sulphate concentrations, acid neutralizing capacity and pH between 1990 and 2016. However, recovery has slowed down in Europe and accelerated in North America since the early 2000s. Acidic episodes have become less severe in line with the recovery of average chemistry, but impacts of changing climatic extremes such as droughts and storms on acidic episodes could be substantial. Key questions on combined effects of climate, land use and deposition on chemical and biological recovery remain to be answered.

15. Catchments in North America and Europe have been exposed to elevated nitrogen deposition for many decades. Ecosystem nitrogen saturation, resulting in enhanced leaching of nitrate and associated acidification, is a concern but so far there are few signs of large-scale increases in nitrate concentrations. Recent trend assessments suggest that nitrate leaching is declining as a response to lower deposition in recent years. However, interactions of deposition, climate and catchment characteristics are likely, but poorly understood, controls of nitrogen leaching. The International Cooperative Programme on Assessment and Monitoring of the Effects of Air Pollution on Rivers and Lakes (ICP Waters) is currently preparing a report with the aim of investigating nitrogen trends and levels in terms of interactions of deposition, climate and land cover. ICP Waters will also contribute to the ongoing revision of the empirical critical loads for nitrogen.

16. Linking water quality to functional biodiversity can provide further insight into the effects of air pollution in surface waters. The functional traits of aquatic organisms (here, macroinvertebrates) have direct consequences for ecosystem functioning, such as litter breakdown, water filtering and nutrient recycling. Initial work on data from selected stations indicates that this approach can elucidate the link between emission of air pollution and ecosystem services.

17. Microplastics and emerging contaminants associated with the urban environment have been found in remote waters in Ireland. The sources of these pollutants are unknown, but atmospheric deposition is possible. Monitoring data from other regions and from air quality would be useful for further exploration.

18. Emission of the pollutant mercury is regulated and included in old and new international conventions and agreements (for example, the Convention, the Minamata Convention on Mercury and the European Union Water Framework Directive).[7] Documentation of levels of mercury in freshwater fish – recipients of mercury pollution – will be important in evaluating whether regulations of emissions have had their intended effect. A general recommendation for monitoring of mercury in freshwater fish is to focus on repeated sampling of the same water body.

19. The ICP Waters monitoring network is tailored to document responses in water chemistry to changes in atmospheric loads of air pollution. New countries have considered contributing (Armenia, Georgia), while several other countries have reinitiated their participation (Ireland, Poland and Spain). Collaboration within the Convention has intensified through the organization of joint meetings with ICP Integrated Monitoring. Reports and results that are delivered continue to be of relevance both under the Convention and other instruments, such as the Minamata Convention and the European Union National Emission Ceilings Directive.[8]

[7] Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, Official Journal of the European Communities, L 327 (2000), pp. 1–72.

[8] Directive (EU) 2016/2284 of the European Parliament and of the Council of 14 December 2016 on

VI. Critical loads and levels

A. Critical loads

20. The International Cooperative Programme on Modelling and Mapping of Critical Levels and Loads and Air Pollution Effects, Risks and Trends (ICP Modelling and Mapping) now has two designated centres: in addition to the Coordination Centre for Effects hosted by Germany, the Centre for Dynamic Modelling was established on 1 January 2020 and is hosted by Sweden. The ICP Modelling and Mapping Chair, in close collaboration with the Coordination Centre for Effects and the Centre for Dynamic Modelling, is publishing a newsletter in order to inform the ICP Modelling and Mapping community of the most recent outcomes of their work.

21. The thirty-sixth meeting of the ICP on Modelling and Mapping Task Force was organized by and held in close collaboration with the Chair of the Task Force, the Coordination Centre for Effects and the Centre for Dynamic Modelling (online, 21–23 April 2020).

22. The main tasks achieved by the Coordination Centre for Effects in 2019 and 2020 are the update and revision of the European background database and progress in the update of critical loads databases according to new knowledge gathered via the 2020–2021 call for data, for which first reports were submitted by countries in spring 2020. Regarding its main tasks for the 2020–2021 workplan, the Coordination Centre for Effects is also leading the review and revision of empirical critical loads for nitrogen, for which the literature review was completed in 2019, and the process was further organized in 2020 in close collaboration with contributors to the process. This has been done by means of close communication by the Coordination Centre for Effects within the Convention and towards external experts in the field of effects-oriented activities and by means of the organization of a kick-off meeting in June 2020.

23. The Centre for Dynamic Modelling is currently building its organization and has started work on a report providing an overview of the current status of dynamic modelling work under the Working Group on Effects. The Centre is also already managing the common Working Group on Effects website.[9]

B. Critical levels: Effects of ozone on vegetation

24. The International Cooperative Programme on Effects of Air Pollution on Natural Vegetation and Crops (ICP Vegetation) produced a review of the interactive impacts of ozone and nitrogen on crops, and a report on the evidence of ozone impacts on crops in developing regions.

1. Interactions between ozone exposure and nitrogen application/accumulation in crops

25. ICP Vegetation produced a review of the interactive impacts of ozone and nitrogen on crops, which has been published as a chapter in *Scientific Background Document B*, available from the ICP Vegetation website.[10] Data mining of peer-reviewed scientific literature was carried out for seed yield, seed protein concentration and seed protein yield for field-grown wheat, soybean and rice, with data available from experiments in Europe, the United States of America, China and India. Ozone concentration data on the experimental treatments and N application rate were also extracted from scientific papers.

26. For wheat there was a decline in seed yield with increasing ozone exposure, however, there was no relationship between ozone sensitivity and nitrogen application rate either when ozone exposure was expressed as daily mean concentration or as Accumulated Ozone

the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC, Official Journal of the European Union, L 344 (2016), pp. 1–31.

[9] See www.unece-wge.org.

[10] See http://icpvegetation.ceh.ac.uk.

exposure over a Threshold of 40 ppb (AOT40). Similarly, for seed protein concentration, which increased with increasing ozone exposure, there was no relationship between ozone sensitivity and nitrogen application rate. There was insufficient data availability to carry out the analysis based on stomatal ozone flux. It was concluded that there was no evidence of a requirement to adjust critical levels for ozone effects on crops with respect to nitrogen availability.

27. Seed protein yield (accounting for the combined impact on seed yield and seed protein concentration) was reduced with increasing ozone concentration for soybean, wheat and rice. It was calculated that the improvements in seed protein yield by reducing mean daily ozone concentrations from 37 ppb (representing current conditions) to pre-industrial levels are 200 kg, 10 kg and 70 kg protein/hectare for soybean, rice and wheat respectively.

28. The negative effect of ozone on seed protein yield, and thus nitrogen efficiency, was largest in soybean and smallest in rice, with wheat being intermediate. This means that, with increasing ozone concentration, less of the applied nitrogen is present in the yield at harvest than would be the case at lower ozone concentration, which may mean that additional nitrogen may be lost as a pollutant to water or the atmosphere with increasing ozone concentrations.

2. Evidence of ozone impacts on crops in developing regions

29. The ICP Vegetation Programme Coordination Centre reviewed the literature for field-based evidence of impacts of ambient ozone on crops in countries receiving overseas development assistance. Sources of data included assessments of leaf injury caused by ozone, improved yield quantity and quality reported in studies applying chemical protectants against ozone, and studies reducing the ozone concentration by filtration of ambient air. In addition, the risk of ozone impacts on ozone-sensitive staple crops was assessed though modelling.

30. There is a considerable amount of evidence of ambient ozone impacts on crops from a limited number of locations in China, India and Pakistan. The reduction of crop yield losses due to ozone in these countries is often in the range of 5–20 per cent, with losses of >40 per cent reported in some cases. Crops showing a reduced yield in ambient ozone conditions, based on air filtration studies, include, for example, broad bean, maize, palak, cowpea, soybean and wheat, although the range of crops tested to date is relatively small. Sensitivity to ozone varies between crop species, with legumes such as bean and soybean being identified as very sensitive. Wheat has been identified as sensitive to ozone and some recent Indian wheat cultivars have a higher ozone sensitivity than previous varieties tested.

31. For many countries in developing regions, impacts of ozone on important crops in the region, including staple food crops, are not known. Modelling exercises can be used to predict where impacts might occur, but there are currently insufficient data to verify these predictions in many developing countries.

VII. Emissions

A. Improving emission inventories

1. General Issues

32. The updated *EMEP/EEA air pollutant emission inventory guidebook 2019*. *Technical guidance to prepare national emission inventories* (EMEP/EEA Guidebook)[11] was formally adopted by the EMEP Steering Body during the fifth joint session (Geneva, 9–13 September 2019). The EMEP/EEA Guidebook includes several updates and improvements in the sectoral chapters (energy, industrial processes and product use and agriculture) and in the

[11] Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe/European Environment Agency (EEA), EEA Report No. 13/2019 (Luxembourg, Publications Office of the European Union, 2019). Available at www.eea.europa.eu/publications/emep-eea-guidebook-2019.

general guidance, with better alignment with the *Intergovernmental Panel on Climate Change Guidelines for National Greenhouse Gas Inventories*.[12] This new updated version of the EMEP/EEA Guidebook benefited from the support of the European Environment Agency and its European Topic Centre on Air Pollution, Transport, Noise and Industrial Pollution and from the contributions of several national experts (Denmark, France, Germany, the United Kingdom of Great Britain and Northern Ireland). The next update time (2022 or 2023) should be discussed at the sixth joint session from the perspective of the review of the Protocol to Abate Acidification, Eutrophication and Ground-level Ozone (Gothenburg Protocol), as amended in 2012 (Executive Body decision 2019/4) and of an overall analysis of the emission inventory work under the Convention.

33. Considerations from the experts of the Centre on Emission Inventories Projections regarding the outcomes of the recent reviews of the reported emission inventories raised the question of the priorities to be set in this process. The issue regarding the quality and completeness of the emission inventories reported by the Parties that are likely to be used to support policy processes is still open. The stage 3 review cycle will end in 2020, and it is proposed that: 2021 be considered as a transition year; the strengths and weaknesses of the process be assessed; and there be a focus on the needs of the modellers (in accordance with the Gothenburg Protocol review activities) and on the most sensitive Parties (with respect to the Implementation Committee's recommendations). New principles to frame the next review cycle (supposed to start in 2022) will be investigated in 2020–2021. They should consider material brought by the reviews carried out by the European Union under the National Emission Ceilings Directives (to avoid duplication of work and ensure consistency between both the European Union and Convention frameworks), and lessons learned from the previous cycles. In particular, an option could be to give priority to non-European Union Parties and to Parties for which it seems more difficult to comply with reporting requirements and to apply highest "tier" methods (these countries may arguably be reviewed more often in the future to support improvement of their practices). Another approach could be to carry out review by sectors or topics for all Parties. Analysis will be developed until the end of 2021 to prepare the future stage 3 review process that should be adopted as a decision by the Executive Body in December 2021.

2. Gridded emissions used for modelling

34. In recent years, the Centre on Emission Inventories Projections has developed and improved a gridding system with a resolution of 0.1° x 0.1° longitude/latitude, which uses different spatial proxies for the spatial disaggregation of gap-filled data on Gridding Nomenclature for Reporting (GNFR14) sector level. The Centre prepared gridded data of main pollutants (nitrogen oxides (NO_x), non-methane volatile organic compounds (NMVOCs), ammonia (NH_3), sulphur oxides (SO_x), carbon monoxide (CO) and particulate matter ($PM_{2.5}$, PM_{10}, coarse PM) for the complete time series from 1990 to 2018. Gridded data for heavy metals (HMs) (cadmium - Cd, mercury - Hg and lead - Pb) and persistent organic pollutants (POPs) (Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, dioxins and furans, hexachlorobenzene) were prepared for the year 2018. For the first time, gridded black carbon emissions were prepared (2018 data) in 0.1° x 0.1° longitude/latitude resolution.

35. For the compilation of the gridded data sets, the Centre took stock of numerous data sources, beyond reported national emissions: data from the European Pollutant Release and Transfer Register reporting, especially for Large Point Sources, shipping emission data gathered by the Finnish Meteorological Institute, Emissions Database for Global Atmospheric Research v4.3.1[13] built up by the European Union Joint Research Centre, and expert estimates from the Centre for Integrated Assessment Modelling and the Netherlands Organization for Applied Scientific Research. This gap-filling work still requires high levels of resources despite the semi-automatic gap-filling system developed by the Centre on Emission Inventories Projections, and a decision on mandatory reporting of historical gridded

[12] See www.ipcc-nggip.iges.or.jp/.
[13] See https://edgar.jrc.ec.europa.eu/overview.php?v=431.

emission with a 0.1° x 0.1° latitude/longitude resolution for the years 1990, 1995, 2000, 2005 and 2010 will be required from the Executive Body.

3. Black carbon emissions

36. Black carbon emission data are gathered on a voluntary basis from the Parties following the reporting process. Despite a large number of Parties voluntarily reporting black carbon emissions, the review revealed a number of shortcomings and made a number of recommendations, for example, calling for the EMEP/EEA Guidebook to be improved in terms of the extent to which higher tier black carbon inventory methods are available.

37. A new Working Group on Black Carbon Emissions has now been established under the Task Force on Emission Inventories and Projections, which started to work on the review of emission measurement methods to identify gaps and improvement needs. This analysis should support future updates of the EMEP/EEA Guidebook. Obviously, this work will be also essential from the perspective of the review of the Gothenburg Protocol (in particular, when assessing the relevance of mandatory reporting of black carbon emissions). Moreover, the Working Group will support the development of cooperation with external bodies also interested by this topic, such as the Arctic Monitoring and Assessment Programme secretariat and the Intergovernmental Panel on Climate Change.

B. Applications for adjustments to emission inventories

38. All submitted adjustment applications – both new and previously approved – have been assessed by the Expert Review Team. In 2020, only one Party, Czechia, submitted a new adjustment application related to NMVOCs and NO_x in the agriculture sector. Moreover, 10 parties (Belgium, Denmark, Finland, France, Germany, Hungary, Luxembourg, the Netherlands, Spain and the United Kingdom of Great Britain and Northern Ireland) submitted annex VII for applications already approved. Recommendations to the EMEP Steering Body are provided in the report on review of adjustment applications (ECE/EB.AIR/GE.1/2020/10–ECE/EB.AIR/WG.1/2020/21). Approved adjustments reported in annex VII have been imported into the website tool, where all information can easily be viewed and compared.[14]

39. During the thirty-ninth session of the Executive Body (Geneva, 9–13 December 2019), an agreement was found regarding the possibility, for the sake of sound use of scarce resources, of down-prioritizing the review of compliance with emissions reduction obligations for historical years – i.e. prior to 2019 – as of 2020 for Parties to the amended Gothenburg Protocol (Executive Body decision 2019/2). This decision is expected to have an impact on and lighten the review process of adjustment applications submitted in 2022 and onwards.

VIII. Monitoring and modelling

A. Revision of the monitoring strategy

40. The revised monitoring strategy for EMEP for the period 2020–2029 was formally adopted by the Executive Body in December 2019 (Executive Body decision 2019/1). Its implementation will give priority to drivers to achieve sustainable long-term high-quality monitoring and continuous update of guidelines and quality assessment initiatives (for example, intercalibration exercises). Special care will be accorded to participation of Parties from the Eastern Europe, the Caucasus and Central Asia region to extend the coverage of the EMEP network. Cooperation with other air quality monitoring networks running at the global scale (such as the Global Atmosphere Watch programme of the World Meteorological Organization) or at the European scale (like the regulatory air quality reporting networks under the relevant European Union Directives and the Aerosols, Clouds, and Trace gases

[14] See http://webdab1.umweltbundesamt.at/adjustments_GP.

Research InfraStructure Network (ACTRIS) project) is also an essential aspect of the revised monitoring strategy.

B. Lessons learned from the last EMEP field campaign

41. In the short term, an important aspect of the EMEP workplan relates scientific developments around the last EMEP field campaign (winter 2017/18) focused on carbonaceous compounds (and black carbon) in PM and their sources with the implementation of high time-resolution and online devices such as multi-wavelengths aethalometers. Chemical analysis of relevant tracers like levoglucosan completed the network. Twenty-two countries participated to the field campaign and 57 sites were monitored. The Chemical Coordinating Centre gathered and processed all data with quality controls.

42. The database is now to be used by the modelling teams from the Meteorological Synthesizing Centre-West and the Meteorological Synthesizing Centre-East and by national experts to assess current models' performances in reproducing carbonaceous compounds concentrations in Europe. A new model intercomparison exercise called EuroDelta-Carb has been launched this year under the aegis of the Task Force on Measurements and Modelling, as a follow-up to the EuroDelta initiatives.

43. Fourteen European models are involved in this model intercomparison exercise conducted in cooperation with the European Union Copernicus Atmosphere Monitoring Service. This new modelling experiment aims to test current air quality models' capacities to correctly simulate PM chemical composition and to assess the sensitivity of model responses to PM emission inventory. This work should support investigations into the qualification of the condensable part in PM (see below). EuroDelta-Carb will also elaborate material for assessing the quality of reported black carbon and benzo(a)pyrene emissions (since black carbon and B(a)P concentrations will be modelled and compared to observations), especially in the residential heating sector.

44. Cooperation with the Copernicus programme will develop on two aspects: the model evaluation framework (EMEP and Copernicus approaches will be brought closer); and the emission inventories. Copernicus has developed a new regional air pollutant emission inventory based on the EMEP one, but with corrections of PM in the residential and road traffic sectors likely to better account for the condensable part of PM. Comparison of model results associated with various emission inventories with observations from the EMEP intensive observation period will help in assessing the value-added of this "science-based" emission inventory compare to the official one, and will bring valuable scientific insights to support current work on the condensable part of PM.

IX. Linking the scales

A. The Expert Panel on Clean Air in Cities

45. The first meeting of the Expert Panel on Clean Air in Cities – established under the aegis of the Task Force on Integrated Assessment Modelling – took place in Bratislava on 27 November 2019. About 80 participants attended the meeting. The need to combine local and regional modelling and measurement tools for a better analysis of the impact and efficiency of local, national and international policies was highlighted. Local authorities are not always aware of the importance of long-range transport in air pollution patterns that affect their city. Even in national methodologies for cost-benefit analysis of projects or policy measures, transboundary impacts are omitted in most countries. Conversely, cities are sources that export their pollution and influence trends in the air pollutant regional background.

46. Therefore, multiscale modelling should be developed, and the Meteorological Synthesizing Centre-West presented recent developments in downscaling of EMEP/Meteorological Synthesizing Centre-West model results at the fine city scale. The

approach, called uEMEP, has been tested for countries where detailed emissions or proxy data are available together with extensive observations data sets.

47. The Panel also highlighted limited data availability on the costs, air quality benefits and co-benefits of local measures, particularly those involving behavioural change (for example, modal shift in transport).

B. Hemispheric transport of air pollution

48. The Task Force on Hemispheric Transport of Air Pollution held its first meeting with its new leading team (Canada and the United States of America being leading countries, supported by vice-chairs nominated by Germany and Poland). The revised mandate of the Task Force was adopted by the Executive Body in December 2019 (decision 2019/9). Priorities in future work will deal with development of a cooperative framework between regional and global modellers in North America, Europe and Asia. According to previous work, ozone remains the most sensitive pollutant regarding hemispheric transport, and work to better characterize trends in global source-receptor relationships, the role of methane in ozone production, and ozone fluxes to vegetation at the global scale will develop in close cooperation with the Task Force on Measurements and Modelling more focused on the regional issues (ECE domain).

X. The condensable issue

49. Modelling of PM and use of expert emissions for primary PM (PPM) strongly suggest that PM emissions in Europe are currently underestimated, and condensable PM[15] from the residential combustion sector, in particular wood burning, is a key source for these missing emissions. At present, the treatment of condensables in reported EMEP emission inventories varies from one country to another and from one emission source to another. However, to a large extent, the condensable component is missing in the emission estimates. In addition to causing underestimation of modelled PM, the lack of the condensable component can strongly influence air pollution concentration maps and the source receptor matrices used in integrated assessment modelling.

50. An extensive discussion developed during the thirty-ninth session of the Executive Body about the science and policy aspects of the question of accounting for the condensable part in PM emissions. The Parties agreed on the need to fix the scientific framework independently of the policy consequences, and mandated the EMEP Steering Body to provide a review of the main stakes and state-of-the-art insights behind the question of condensables (ECE/EB.AIR/144, paras. 17–22). Thanks to the support of the Nordic Council of Ministers, an online workshop was organized in March 2020 to carry out such a review. About 30 experts from various scientific fields (emission, modelling, monitoring, technological aspects) and from different countries participated actively to the event to discuss the condensable PM challenges and possible solutions thereto.

51. The experts attending the workshop confirmed the importance of condensables in PM and agreed that, although residential wood combustion was a priority source, it was important to take stock of other sources that might prove to be important (road transport and some industrial sectors). They agreed that condensables should be included in future emission inventories and modelling work. There was an urgent need to define a common framework because the current situation was unfair, with various approaches and definitions producing very different PM emissions in national reporting for the same activity (for example, burning one unit of wood). Assumptions behind national emissions should be documented. In 2019, the EMEP Steering Body and the Working Group requested Parties to document in their informative inventory reports how they dealt with the condensable part of PM emissions they reported, sector-by-sector. That effort should be further strengthened with support from the Centre on Emission Inventories and Projections and the experts of the Task Force on

[15] The condensable component of particulate matter is released as a gas but forms particles when it is diluted and cools down.

Emission Inventories and Projections. In parallel, a group of experts would prepare a review of work about the methodologies and tools available to measure the condensable in PM emissions and establish more accurate emission factors. From a longer-term perspective, some of the approaches discussed could be good candidates for development as a future emission measurement standard.

52. Because best emission estimates are needed to carry out modelling work, especially in the framework of the review of the Gothenburg Protocol, the experts recommended the use of science-based corrected emission inventories that account for the condensable part of PM. The Copernicus Atmosphere Monitoring Service includes an activity dedicated to emissions and has developed such a tool. This inventory could be considered as a good no-regrets candidate to account for condensables from residential heating PM emissions in air quality simulations. However, if used for supporting EMEP modelling work, it should clearly be documented so that countries can be informed about the differences with official emission data they report, and perhaps improve the assumption they make for emissions. This work will be carried out in the upcoming year.

53. The draft report of the workshop will be discussed by the EMEP Steering Body in September 2020, and outcomes will be reported to the Executive Body in December 2020.

XI. Review of the Protocol to Abate Acidification, Eutrophication and Ground-level Ozone, as amended in 2012

54. Priorities in the scientific work carried out by bodies under EMEP and the Working Group on Effects will be driven by the needs of the review of the Gothenburg Protocol. The contributions to the review by the scientific bodies will focus on key questions included in section D of the annex to decision 2019/4 on the review of the Gothenburg Protocol, as amended in 2012. For the convenience of the reader, the key questions are presented below:

(a) Quality and consistency of inventories, and in particular black carbon emissions inventories, and condensables in PM, including emissions factors;

(b) Definition of black carbon;

(c) Additional types of non-forested terrestrial ecosystems for monitoring and modelling the effects of air pollution;

(d) Update of critical loads for the analysis of the effectiveness of policies;

(e) Effects of air pollution on biodiversity as a basis for critical levels/loads calculations;

(f) Metrics for assessing ozone damages to crops and ecosystems and interactions with other pollutants and climate change;

(g) Accounting for linkages with climate change and land use in effects indicators;

(h) Analysis of costs and benefits, including costs of inaction;

(i) Further input from the Task Force on Hemispheric Transport of Air Pollution on ozone and ozone precursors and PM, including in response to questions proposed by the Working Group on Strategies and Review and recommended control strategies for further modelling by the Task Force;

(j) Definition of human health impact metrics;

(k) Trend analysis in emissions/concentrations/depositions/impacts at the multi-scale dimension, and consideration of impact of international policies on trends;

(l) Ways to address barriers to implementation, including for existing sources.