United Nations ECE/EB.AIR/WG.1/2013/3

Economic and Social Council

Distr.: General
6 September 2013

English only

Economic Commission for Europe

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

Working Group on Effects

Thirty-second session
Geneva, 12 and 13 September 2013
Item 4 of the provisional agenda
Recent results and updating of scientific and technical knowledge

2013 joint progress report on the activities of the International Coordinated Programmes and the Joint Task Force on the Health Aspects of Air Pollution

Report by the Extended Bureau of the Working Group

Summary

At its twenty-seventh session in December 2009, the Executive Body for the Convention on Long-range Transboundary Air Pollution decided that the Working Group on Effects would prepare an annual review of the activities and results of the International Cooperative Programmes (ICPs), the Joint Task Force on the Health Aspects of Air Pollution (Task Force on Health) and the Joint Expert Group on Dynamic Modelling (ECE/EB.AIR/99/Add.2, item 3.1).

The present report was drafted by the Extended Bureau of the Working Group (comprising the Bureau of the Working Group; the Chairs of the ICP task forces, the Task Force on Health and the Joint Expert Group on Dynamic Modelling; representatives of the ICP programme centres; and invited experts) in cooperation with the secretariat. The review of activities is based on the information provided by the lead countries and the programme centres, and is submitted in accordance with the Convention's 2012–2013 workplan (ECE/EB.AIR/109/Add.2, item 3.1 (b)).

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I. Introduction

1. The present report highlights some outcomes of the work under the Working Group on Effects during the period 2012–2013 considered to be of interest for policy purposes. Through their strong networks and centres, the subsidiary bodies under the Working Group have been able to maintain their activities in spite of the economic crisis. In fact, the outputs from many of these subsidiary bodies have increased in recent years. This has been evident from the thematic reports produced by several International Cooperative Programmes (ICPs), but also, in particular, from the common integrated reports from the Working Group system. These reports have in general been directed towards well-identified societal needs but also, in some cases, have been produced at the direct request of the Executive Body and other bodies under the Convention on Long-range Transboundary Air Pollution.

2. In 2012, two common reports were published in support of the revision of the Convention's Protocol to Abate Acidification, Eutrophication and Ground-level Ozone (Gothenburg Protocol): a guidance document on health and environmental improvements (informal document No. 4 for the fiftieth session of the Working Group on Strategies and Review); and a report on impacts of air pollution on ecosystems, human health and materials under different Gothenburg Protocol scenarios (informal document No. 14 for the thirtieth session of the Executive Body). The Working Group on Strategies and Review requested an update of the guidance document, with the final emission figures from the Gothenburg Protocol amendments, and this update will be presented at the thirty-second session of the Executive Body in December 2013.

3. In 2013, a strong focus has been on the compilation of a common Working Group on Effects report on the benefits of air pollution control for biodiversity and ecosystems services. This report is presented separately (ECE/EB.AIR/WG.1/2013/14). Several of the activities and results have received increased attention through brochures, which in several cases have been translated into Russian and French. In addition, a large number of scientific publications have been published in this area, thus strengthening the scientific credibility of the effects-oriented work under the Convention.

4. In 2012–2013, the Working Group's subsidiary bodies collaborated with the European Commission in its work on the new Thematic Strategy on Air Pollution. This is of particular importance for the ICP on Modelling and Mapping of Critical Loads and Levels and Air Pollution Effects, Risks and Trends (ICP Modelling and Mapping), but also for the ICP on Effects of Air Pollution on Natural Vegetation and Crops (ICP Vegetation), in preparing scenarios for the revision of the European Union (EU) National Emission Ceilings Directive.[1] The World Health Organization (WHO)-led project, review of evidence on health aspects of air pollution (REVIHAAP),[2] is also of importance for the work of the Joint Task Force on Health Aspects of Air Pollution (Task Force on Health) of the WHO/European Centre for Environment and Health (ECEH) and the Executive Body for the Convention.

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[1] Directive 2001/81/EC of the European Parliament and of the Council of 23 October 2001 on national emission ceilings for certain atmospheric pollutants.

[2] See http://www.euro.who.int/en/what-we-do/health-topics/environment-and-health/air-quality/publications/2013/review-of-evidence-on-health-aspects-of-air-pollution-revihaapinterim-report.

II. Selected key results

A. Impacts of air pollution on human health

5. The health effects are important determinants for policies aiming at the reduction of air pollution. The recent results from the WHO Global Burden of Disease Study 2010[3] clearly emphasized the role of air pollution for human health and well-being. The study ranked household air pollution from solid fuels and ambient air pollution (assessed as annual fine particulate matter ($PM_{2.5}$) concentration) as the fourth and eighth leading global risk factors for burden of disease, respectively. As part of this analysis, ambient air pollution accounted for 3.1 million deaths and around 3.1 per cent of global disability-adjusted life years.

6. This report, as well as the recent findings from the WHO REVIHAAP project, which is an evidence review on the health aspects of air pollution in support of the current revision of EU air quality policy, were presented and discussed at the sixteenth meeting of Task Force on Health in 2013 (see ECE/EB.AIR/WG.1/2013/11). New scientific evidence supports the conclusions of the WHO air quality guidelines,[4] last updated in 2005, and indicates that the effects in some cases occur at air pollution concentrations lower than those serving to establish those guidelines. A considerable amount of new scientific information on the adverse effects on health of particulate matter (PM), ozone and nitrogen dioxide, observed at levels commonly present in Europe, has been published in recent years. The REVIHAAP report provides scientific arguments for taking decisive actions to improve air quality and reduce the burden of disease associated with air pollution in Europe. As the results and conclusions are also relevant for United Nations Economic Commission for Europe (ECE) member States outside the EU, it is important that the REVIHAAP findings are disseminated and made available in other languages, in particular in Russian. The Executive Body is recommended to consider actions in order to further disseminate the findings.

7. In view of recently published WHO/Joint Task Force on Health brochure on the *Health effects of particulate matter — policy implications for countries in Eastern Europe, the Caucasus and Central Asia*,[5] the Task Force on Health concluded that the monitoring of PM is very limited in countries in the Eastern part of the ECE region, with only a small number of monitoring stations. The Task Force highlighted the importance of quantitative knowledge about sources and levels of and trends in emissions of primary particles and precursor gases in finding the best control strategy for reducing risks and decreasing the burden of disease from air pollution.

8. The Task Force on Health has also reviewed the evidence on the health effects of biomass combustion for residential heating. The need to mitigate this important source of air pollution exposure is emphasized, as it will be difficult to tackle outdoor air pollution

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[3] WHO, Global Burden of Diseases, Injuries, and Risk Factors Study 2010. See http://www.healthmetricsandevaluation.org/gbd/research/project/global-burden-diseases-injuries-and-risk-factors-study-2010.

[4] *Air Quality Guidelines — Global Update 2005 — Particulate matter, ozone, nitrogen dioxide and sulfur dioxide*. Available from http://www.who.int/phe/health_topics/outdoorair/outdoorair_aqg/en/index.htmlhttp://www.who.int/phe/health_topics/outdoorair/outdoorair_aqg/en/index.html.

[5] Available from http://www.euro.who.int/en/what-we-publish/abstracts/health-effects-of-particulate-matter.-policy-implications-for-countries-in-eastern-europe,-caucasus-and-central-asia.

problems in many parts of the ECE region without addressing the combustion of biomass for heating at the household level.

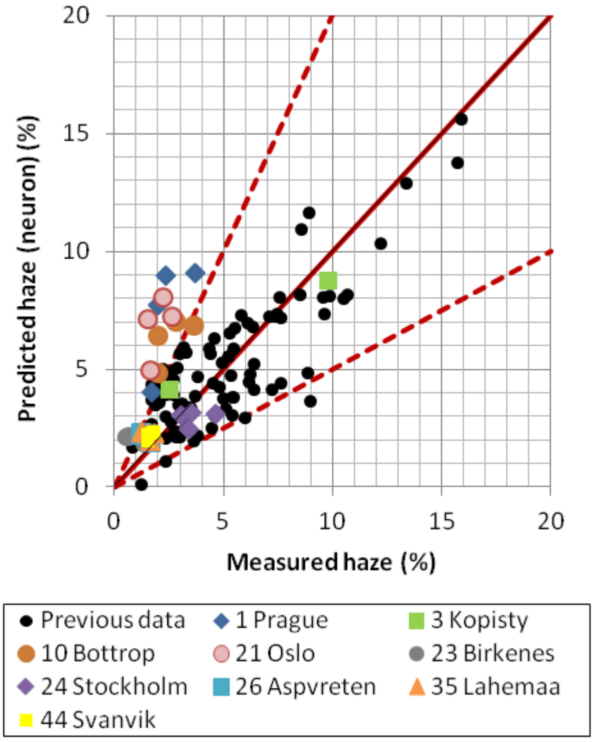
B. Effects of black carbon (soot) on materials

9. Black carbon (soot) is not only of importance for its effects on climate and health; black carbon and other particles are also known to cause soiling effects to materials. During 2008–2012, based on a request from the Executive Body (ECE.EB.AIR/106/Add.1, decision 2010/2), the ICP on on Effects of Air Pollution on Materials, including Historic and Cultural Monuments (ICP Materials) performed exposure studies on modern glass, including development of dose-response functions. The soiling effects on transparent materials (glass) were quantified by changes in haze (ratio of direct and diffuse transmittance expressed in per cent), and non-transparent materials by changes in reflectance compared to unsoiled surfaces. The four-year exposure of modern glass showed that the threshold of 1 per cent of haze (corresponding to visual nuisance felt by human eyes) was exceeded after one year for all the sites and can reach 5 per cent after four years (even 8–10 per cent in two specific sites). However, haze tended to rapidly saturate around values less than 2 per cent for rural sites, whereas the evolution was still linearly increasing for urban and industrial sites after four years. The results are to be reported in 2013.

10. The work also included the development of new dose-response functions both for transparent and non-transparent materials. The previously developed dose-response function was deduced from one- or two-year exposure data and only from one set of long-term data (Paris). This new long-term exposure (2008–2012) in 11 sites showed that the function was site-dependent (rural versus urban and industrial). The two kinds of dose-response functions for haze of modern glass that were developed, including sulphur dioxide (SO_2), nitrogen dioxide (NO_2) and coarse particulate matter (PM_{10}) as pollution parameters, were both validated with the new data set. Preliminary results demonstrated that haze could be predicted to within about a factor of 2, except for three sites, where the haze was overestimated.

Figure 1

Test of dose-response function with the new data set from the 2008–2012 exposure campaign



Notes: Red line indicates that predicted haze is equal to the measured haze (dash lines within a factor of 2). More information can be found in the progress report on the effects of air pollution on materials (ECE/EB.AIR/WG.1/2013/7).

C. Benefits of air pollution control on biodiversity and ecosystems services

11. The report on the benefits of air pollution control for biodiversity and ecosystems services (ECE/EB.AIR/WG.1/2013/14) has been a key activity for the Working Group on Effects community in 2012–2013. In the report, some examples of data were given on how air pollution abatement policies provided benefits for ecosystem services and biodiversity and how further benefits could be achieved in the future. The report was based on data available from several ICPs under the Working Group on Effects. The advantages and disadvantages of valuation in monetary and non-monetary terms were also discussed. The report also put forward some conclusions and policy recommendations for further consideration by the Executive Body and other bodies under the Convention.

12. The report's main conclusions are:

(a) Awareness of ecosystem services, including biodiversity, in both monetary and non-monetary terms helps to assess the real benefits of air pollution control;

(b) It is very encouraging that there are signs of chemical and biological recovery from acidification. It remains uncertain whether full recovery of biodiversity from adverse effects of historic air pollution will be possible;

(c) Further air pollution abatement will continue to reduce the threat to loss of biodiversity; however, “no net loss of biodiversity” will not be achieved by 2020 under the revised Gothenburg Protocol;[6]

(d) With full implementation of the revised Gothenburg Protocol, further benefits are expected for ecosystem services, such as improvements in air, soil and water quality and crop production;

(e) Further air pollution abatement policies will enhance the resilience of biodiversity and ecosystem services to climate change.

13. The policy recommendations are:

(a) To halt biodiversity loss and adverse impacts of air pollution on human well-being, policy negotiations should take into account the benefits of air pollution control for ecosystem services in addition to the direct benefits for human health;

(b) More stringent air pollution abatement measures beyond the revised Gothenburg Protocol are required to achieve “no net loss of biodiversity”;

(c) The full benefits of air pollution abatement for ecosystem services (and hence human well-being) have to be assessed and weighed against the costs of more stringent air pollution controls;

(d) The effects-based integrated assessment of policies that address the driving forces of environmental issues could be further balanced by including “no net loss of biodiversity and ecosystem services’ in air, water, soils and vegetation as an explicit endpoint.

D. Decreasing depositions of heavy metals

14. Results of the most recent moss survey conducted in 2010/11 indicated a continuing decline in the deposition of heavy metals over the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP) domain. The European moss survey coordinated by ICP Vegetation provided field-based evidence for spatial patterns and temporal trends in the deposition of heavy metals and nitrogen to vegetation. Temporal trends in concentrations in mosses were in good agreement with trends reported for atmospheric deposition modelled by EMEP. Between 1990 and 2010, the average cadmium and lead concentration in mosses declined by 51 per cent and 77 per cent, respectively, whereas the average modelled cadmium and lead deposition in the EMEP domain declined by 51 and 74 per cent, respectively. Between 1995 and 2010, the average mercury concentration in mosses declined by 23 per cent, whereas the average modelled mercury deposition in the EMEP domain declined by 27 per cent.[7]

15. Input and output budgets, as well as catchment retention for cadmium, lead and mercury in the years 1997–2011 were determined for 15 catchments of the ICP on Integrated Monitoring of Air Pollution Effects on Ecosystems across Europe (ECE/EB.AIR/WG.1/2013/9). Excluding a few sites with high discharge, between 74 and 94 per cent of the lead input was retained within the catchments. Significant cadmium retention was also observed. Almost complete retention of mercury, 86–99 per cent of

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[6] Available from http://www.unece.org/env/lrtap/multi_h1.html.

[7] See report on heavy metals and nitrogen in mosses: spatial patterns in 2010/11 and long-term temporal trends (1990–2010) in Europe (ECE/EB.AIR/WG.1/2013/13) for details.

input, was reported in the Swedish sites. These high levels of metal retention were maintained even in the face of recent dramatic reductions in pollutant loads. Litterfall plus throughfall was taken as a measure of the total deposition of lead and mercury (wet + dry) on the basis of evidence suggesting that, for these metals, internal circulation was negligible. The same is not true for cadmium.

E. Moss surveys shown to be a useful tool for spatial distribution and long-term trends in deposition of persistent organic pollutants

16. A recent review study by ICP Vegetation showed that mosses were suitable organisms for monitoring spatial patterns and temporal trends of atmospheric concentrations or deposition of persistent organic pollutants (POPs), including polycyclic aromatic hydrocarbons, polychlorobiphenyls, polychlorinated dibenzo-p-dioxins and furans (PCDD/Fs), and polybrominated diphenyl ethers (flame retardants). The usefulness of mosses for monitoring spatial patterns was confirmed by the results of a pilot study conducted in 2010 in France, Norway, Poland, Slovenia, Spain and Switzerland.[8] In addition, the results indicate that future heavy moss surveys can also include surveys of POPs.

F. Exceedances of critical loads for acidification in 2030 expected to be back to the 1880 levels

17. The Coordination Centre for Effects has recently recalculated the exceedances and areas at risk based on the new EMEP model with a resolution of 0.50º × 0.25º (about 28 kilometers (km) × 28 km) (EMEP28) longitude-latitude grid for emissions between 1880 and 2030 and most recent critical load database. For emissions for the period 2010–2030, a combination of the revised Gothenburg Protocol and the Current Legislation Scenario (GP-CLE) provided by the International Institute for Applied Systems Analysis was used.

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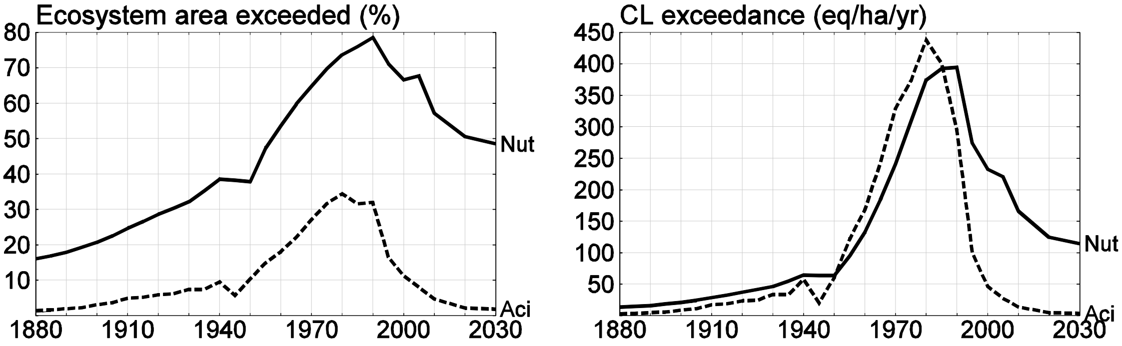
[8] See the report on the effects of air pollution on natural vegetation and crops (ECE/EB.AIR/WG.1/2013/8) for details.

Figure 2

Temporal development since 1880 of the area at risk (in %, left) and magnitude (in equivalents per hectare per year (eq/ha/yr), right) of average accumulated exceedance of acidification (dotted) and eutrophication (solid) using the GP-CLE scenario depositions as of 2010



Source: Modelling and mapping (ECE/EB.AIR/WG.1/2013/10).

18. Assuming the GP-CLE scenario to be implemented as of 2010, figure 2 shows that both the percentage of the area exceeded, i.e., at risk of acidification (left graph), as well as its average accumulated exceedance (AAE) magnitude (right graph) in 2030, are similar to 1880 — i.e., about 2 per cent and 5 eq/ha/yr, respectively. The peaks of the acidified area and exceedance magnitude occur in 1980.

19. The model calculations showed that eutrophication would continue to remain a serious issue under the GP-CLE emissions scenario in 2020, affecting about 50 per cent (54 per cent in the 28 member States of the EU (EU–28)) of the European ecosystem area in 2020 with an AAE of about 125 eq/ha/yr (159 eq/ha/yr in the EU–28).[9] The European area at risk has increased in comparison to computations made with methods and data available for the support of the negotiations of the Gothenburg Protocol revision, i.e., 42 per cent with an AAE of 109 eq/ha/yr on the EMEP resolution of 50 km^2 x 50 km^2. However, note that the old computations for the EU–27 turned out to yield a larger area at risk than the computations made with EMEP–28 and the European critical load database (CL28),[10] i.e., about 62 per cent instead of now 54 per cent. It can be noted from figure 2 that eutrophication due to atmospheric deposition existed already in 1880. The area at risk more than a century ago was computed to have been exceeding by about 20 per cent. This is likely caused by emissions of reduced nitrogen.

20. The geographical patterns of the areas at risk of both acidification and eutrophication under the revised Gothenburg Protocol in 2020, as computed with CL28 and EMEP28, revealed a similar geographical pattern to the old computations. Areas with relatively high exceedances continue to be found in the bordering area of the Netherlands and Germany (acidification) and in the north of Italy and western France (eutrophication). However, in comparing the result of new to old methods, in particular with respect to the risk of eutrophication, lower exceedances are found in, e.g., France, Poland and the United

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[9] Under the Revised Gothenburg protocol (i.e. without CLE) the area at risk of eutrophication in 2020 is 53 per cent (56 per cent in the EU28).

[10] See Posch M, Slootweg J, Hettelingh J-P (eds) 2011. Modelling critical thresholds and temporal changes of geochemistry and vegetation diversity: CCE Status Report 2011, ISBN 978-90-6960-254-7, Bilthoven; www.rivm.nl/cce.

Kingdom of Great Britain and Northern Ireland, and higher ones in Romania, the Russian Federation and Spain. Changes are due to updated critical loads provided by National Focal Centres and an update of the background database to obtain the required higher resolution critical load maps of Europe.

21. Finally, it can be noted that the peaks of eutrophication come a decade later than acidification, due to the fact that policies to curb nitrogen emissions seemed less urgent (emission abatement policies focused on SO_2 reduction) and started later.

G. Effects of ozone on ecosystems services and biodiversity

22. Although plant species vary in sensitivity to ozone, which is likely to affect species composition in plant communities, it is not clear yet how ozone affects plant diversity and species abundance in established plant communities in the field. ICP Vegetation conducted a review on the impacts of ozone pollution on ecosystem services and biodiversity.[11] Impacts on ecosystem services will affect human well-being. The review describes how ozone exposure:

(a) Reduces primary production and therefore affects carbon cycling. Ozone reduces carbon sequestration in the living biomass of trees, providing a positive feedback to global warming. The adverse effect of ozone on primary productivity will also reduce the size of vegetation, providing a sink for ozone deposition, resulting in higher ozone concentrations in the air;

(b) Affects nutrient cycling directly or indirectly;

(c) Affects the opening of leaf pores and therefore water cycling;

(d) Reduces crop and timber production, with considerable economic consequences;

(e) Affects the synchronization of flowering and the presence of pollinating species. Ozone also reduces seed number, fruit number and weight, affecting the reproductive success of plants.

H. Biodiversity improvement observed in surface waters

23. Biodiversity is affected by the changes in water chemistry. Trend results based on approximately 1.6 million benthic macro invertebrates from 5,010 samples in 55 rivers and 34 lakes collected between 1982 and 2011 as part of national monitoring programmes in the Czech Republic, Germany, Latvia, Norway, Sweden and the United Kingdom showed a net increase in biodiversity during the last 25 years. The increase is statistically significant for most of the rivers, while the changes in lakes are less pronounced. Worldwide, biodiversity of freshwaters is declining, while the biodiversity of the sites in the ICP Waters programme are increasing. Overall, this suggests that reduction of sulphur emissions has been successful for biodiversity and that the biodiversity of rivers is more vulnerable to changes in environmental conditions than the biodiversity of lakes, highlighting the importance of careful management of rivers. Different results for lakes and streams could be related to

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[11] See report on the effects of air pollution on natural vegetation and crops (ECE/EB.AIR/WG.1/2013/8) for details.

greater improvement in the water chemistry in streams (fewer acidic episodes) and differences in dispersal limitations and recolonization between lake and river ecosystems.[12]

I. Biodiversity in terrestrial ecosystems

24. Chronic nitrogen (N) deposition is a well-known threat to biodiversity. Long-term monitoring data from 28 forest sites with a total of 1,335 permanent vegetation sampling units from northern Fennoscandia to southern Italy were used to study temporal trends in species cover and diversity. It was found that the cover of plant species that prefer nutrient-poor soils (oligotrophic species) decreased the more the measured N deposition exceeded the empirical critical load (CL) for eutrophication effects (highly significant correlation). Although species preferring nutrient-rich sites (eutrophic species) did not experience a significant increase in cover, in comparison to oligotrophic species they had a higher proportion among new occurring species. The observed gradual replacement of oligotrophic species by eutrophic species as a response to N deposition was consistent on the European scale. Contrary to species cover changes, neither the decrease of species richness nor of homogeneity correlated with nitrogen CL exceedance.[13]

J. Carbon budgets of forest stands under a changing climate

25. Carbon sequestration to forests is of crucial importance for climate change mitigation. The ICP on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests) plots offer a unique option for assessing the sequestration over time and for using these data to model the long-term development given expected changes in climate over this century. In a study using 28 selected ICP Forests Level II plots, it was shown that carbon sequestration is expected to increase over the coming decades. The model calculations were based on emissions scenarios A1B and B1 of the Intergovernmental Panel on Climate Change special report on *Emissions Scenarios*.[14,15] Climate projections for the time periods 2040–2059 and 2080–2099 show in general that the carbon sink function will increase under expected future climate conditions. Under changed climate (A1B scenario, 2080–2099 compared with 1990–2009) the carbon fluxes were simulated to be accelerated on average by +35 per cent for gross primary production, +55 per cent for maintenance respiration, +22 per cent for growth respiration, +20 per cent for heterotrophic respiration, +26 per cent for net ecosystem production, and +35 per cent for net biome production. Compared with the reference scenario, the increase in carbon stocks accelerates by 47 per cent for vegetation and by +17 per cent for leaf plus fine root litter pools. In contrast, the increase is diminished for coarse woody debris, and the decrease is accelerated for soil organic carbon (figure 3).[16]

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[12] See report on effects of air pollution on rivers and lakes of the ICP on Assessment and Monitoring of Acidification of Rivers and Lakes (ECE/EB.AIR/WG.1/2013/6) for details.

[13] See report on integrated monitoring (ECE/EB.AIR/WG.1/2013/9) for details.

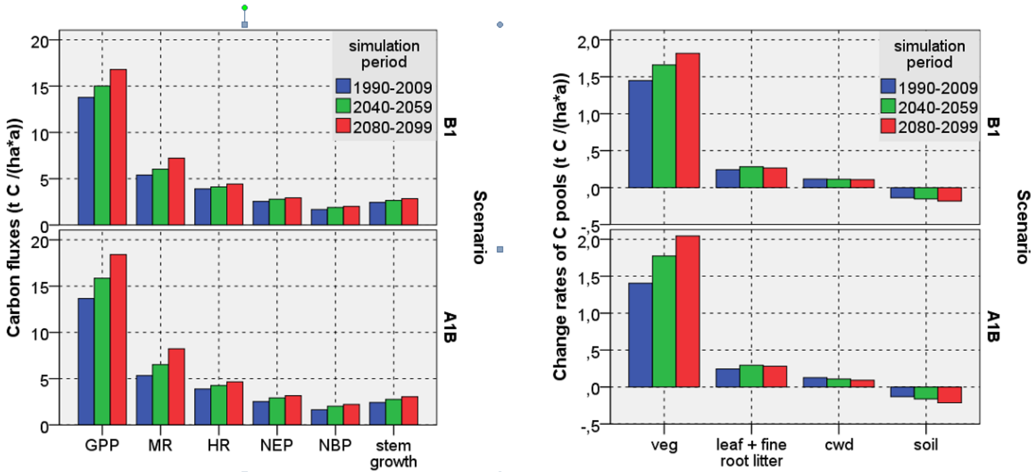
[14] Nebojsa Nakicenovic and others (Cambridge, United Kingdom, Cambridge University Press, 2000).

[15] See, e.g., http://www.ipcc.ch/ipccreports/tar/wg1/029.htm.

[16] See the technical report of ICP Forests (ECE/EB.AIR/WG.1/2013/5) for details.

Figure 3

Simulation results on carbon fluxes and balances (left) and on change rates of carbon pools (right) for the periods 2040–2059 and 2080–2099 compared with the reference period (1990–2009)



Source: Technical report of ICP Forests (ECE/EB.AIR/WG.1/2013/5).

Notes: Results are averages over all plots for gross primary production (GPP), maintenance respiration (MR), heterotrophic respiration (HR), net ecosystem production (NEP), net biome production (NBP), vegetation (veg), leaf and fine root litter, coarse woody debris (cwd) and soil.