Implications of current knowledge on N deposition and impacts for policy, management and capacity building needs: CLRTAP

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Introduction

The 1979 Convention on Long-range Transboundary Air Pollution (CLRTAP[1]) addresses major environmental problems caused by transboundary air pollution in the UNECE region (North America, Europe, and large parts of Northern and Central Asia). It has been implemented through eight Protocols[2], two of which deal with reactive nitrogen. The most recent and important one is the Gothenburg Protocol which aims at simultaneously reducing eutrophication, acidification and tropospheric ozone pollution.

The Convention has been one of the most successful regional agreements ever established:

- Air pollution effects have been reduced considerably especially for acidification, health, vegetation and materials damage due to sulphur dioxide, heavy metal and POP pollution as well as peak ozone concentrations. Reactive nitrogen pollution on the other hand, has improved but not as much as for the other pollutants. Calculations show that once the Gothenburg Protocol is fully implemented[3] the area in Europe with excessive risks of acidification will shrink from 93 million hectares in 1990 to 15 million hectares. The region with risks of N deposition leading to eutrophication will only fall from 165 million hectares in 1990 to 108 million hectares. Also, the number of days with excessive ozone levels will be halved, and the exposure of vegetation to excessive ozone levels will be 44% less than in 1990.
- The Convention has connected different political systems with similar environmental problems. This has been very important in the last decades of the past century, and still applies in linking North American, EU and Eastern European, Caucasian and Central Asian countries. In addition, the Convention has linked with countries and

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[1] http://www.unece.org/env/lrtap/

[2] http://www.unece.org/env/lrtap/status/lrtap_s.htm

[3] The target year of the Gothenburg Protocol is 2010.

other regional environmental agreements outside the UNECE region, especially in Asia.

- The Convention has helped to develop international environmental law, especially on air pollution. For instance, the 1999 Gothenburg Protocol has influenced in many ways the development of the EU Directive on National Emission Ceilings[4].
- The Convention has provided an institutional framework[5] facilitating the use of science to develop and implement policy. It comprises large unique networks for scientific monitoring, modelling and research, with a strong interface to policymaking. The database and methodologies (and the networks producing them) have ensured a direct transformation of scientific evidence into policy of not only CLRTAP but other processes as well. The scientific results have been be used to define limit values, best available techniques and economic instruments in the annexes to protocols and guideline documents, and to develop and implement the effects-based approach (see next section) to set targets. This institutional framework has set an example for other regions that are developing air pollution controls.

Critical loads in air pollution policies: the effects-based approach

The effects-based approach developed in the Convention minimizes environmental and health risk indicators, such as critical loads exceedances[6], and abatement costs to design regional emission reduction requirements. In other words, emission reduction requirements are derived from environmental and health targets using integrated assessment models (see below). Such models derive national emission ceilings for individual pollutants, which in Europe also include ammonia and nitrogen oxides.

National critical load data for European and in Canada are generated by a network of National Focal Centres (NFCs) under the International Cooperative Programme on Modelling and Mapping (ICP M&M)[7]. NFCs cooperate with the Coordination Centre for Effects (CCE)[8] to develop modelling methodologies and European databases for critical loads. The CCE reports on this work to the Task Force of the ICP M&M which in turn transmits it to the responsible CLRTAP bodies. The methodology is constantly updated in the CLRTAP's Modelling and Mapping Manual[9]. The organization of effects-based air pollution work under the Convention is described e.g. at www.unece.org/env/lrtap/, Spranger et al. (2008) and Johansson et al. (2004).

Exceedances of the critical load of acidity and of nutrient nitrogen, among other effects, have been used in European pollution abatement policy for defining emission reduction requirements in CLRTAP as well as in the European Union (National Emission Ceilings Directive 2001[10]; Thematic Strategy Air 2005[11]).

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4 http://ec.europa.eu/environment/air/pdf/nec_eu_27.pdf

5 http://www.unece.org/env/lrtap/conv/CLRTAP%20Organizational%20Structure.pdf

6 critical load exceedance = deposition minus critical load

7 www.icpmapping.org

8 http://www.mnp.nl/en/themasites/cce/index.html

9 http://icpmapping.org/cms/zeigeBereich/5/manual_und_downloads.html

10 http://ec.europa.eu/environment/air/pdf/nec_eu_27.pdf

Integrated assessment models (e.g. the RAINS/GAINS model[12] in Europe and RAISON (Lam et al 1998) in Canada) use these data and methods in analyses of future scenarios. They take into account regionally variable critical loads, emission sources, atmospheric transport and depositions, abatement technologies with related costs, and activity projections (agriculture, traffic, energy use etc.). Such models link pollution sources and effects, allocate costs and benefits and advise policy on prioritising emission abatement.

In Canada, critical loads assessment of sulphur deposition effects have been used by Environment Canada and provincial jurisdictions to set S emission levels and help evaluate emission control policies such as the Canada-Wide Acid Rain Strategy for Post 2000 (CCME 1998[13]). CL approaches are currently not being used to assess N emission policies however.

In the United States, the critical loads approach is not an officially accepted approach to ecosystem protection and is not specifically required in the Clean Air Act. Nevertheless, recent activities within federal and state agencies, as well as the research community, indicate that critical loads may be emerging as a useful ecosystem protection, communication and program assessment tool.[14]
Within the U.S. National Atmospheric Deposition Program, an ad hoc critical loads committee[15] was formed which coordinates efforts to explore the potential uses of critical loads in policy development and program implementation.
The ninth biennial progress report completed under the 1991 United States–Canada Air Quality Agreement, prepared by the bilateral U.S.-Canada Air Quality Committee[16], included for the first time estimates of critical loads in acid-sensitive lakes in the northeastern United States.

Policy outcomes

The application of the effects-based approach in the Gothenburg Protocol has resulted in emission ceilings for 2010 for four pollutants: sulphur, nitrogen oxides (NO_x), volatile organic carbon excluding methane (VOC), and ammonia. These ceilings were negotiated on the basis of scientific assessments of pollution effects and abatement options as described above. Parties whose emissions have a more severe environmental or health impact and whose emissions are relatively cheap to reduce will have to make the biggest cuts. Once the Protocol is fully implemented, Europe's sulphur emissions should be cut by at least 63%, its NO_x emissions by 41%, its VOC emissions by 40% and its ammonia emissions by 17% compared to 1990.

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[11] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2005:0446:FIN:EN:PDF

[12] http://www.iiasa.ac.at/rains/ciam.html

[13] http://www.ccme.ca/assets/pdf/1998_acid_rain_strategy_e.pdf

[14] In 2004, the National Research Council recommended that the U.S. Environmental Protection Agency (EPA) consider using critical loads for ecosystem protection. In 2005, EPA included a provision in its Nitrogen Dioxide Increment Rule that individual states may propose the use of critical loads information as part of their air quality management approach, in order to satisfy requirements under Clean Air Act provisions regarding "prevention of significant deterioration." Federal land management agencies, such as the National Park Service and the U.S. Forest Service, developed specific recommendations for using the critical loads approach as a tool to assist in managing federal lands.

[15] http://nadp.sws.uiuc.edu/clad/

[16] http://www.ec.gc.ca/cleanair-airpur/caol/canus/report/2008CanUs/eng/tdm-toc_eng.cfm

However, N deposition has remained much higher than critical loads in large parts of Europe, and it has barely changed over the last decade, causing widespread eutrophication of terrestrial ecosystems and causing (or slowing down recovery from) acidification. The Gothenburg Protocol has therefore not been sufficient to significantly reduce risks from nitrogen deposition, including nutrient imbalances and biodiversity degradation, and more nitrogen emission reductions are necessary (see e.g. analyses of the CLRTAP Working Group on Effects from 2007[17], 2009[18]).

The European Commission has reacted to this and other air pollution related threats by establishing the Thematic Strategy on Air Pollution (TSAP 2005). Its objectives are inter alia to reduce by 2020 the ecosystem area with excess of critical loads of eutrophication by 43% from the 2000 level. According to more recent analyses, this would need a reduction of NO_x emissions by about 58% and NH_3 emissions by about 22% from the 2000 level. This means that in 2020 most reactive nitrogen emissions within the EU will be NH_3 emissions from agriculture.

N deposition in North America has also not declined over the previous decades; in some regions it has increased, in others it has remained unchanged (Galloway et al. 2003; National Atmospheric Deposition Program; http://nadp.sws.uiuc.edu/). The Clean Air Act (CAA) and CAA Amendments led to substantial decreases in SO_2 but not NO_x emissions; NH_3 emissions are not covered by the CAA. In Canada, the pattern of NO_x emissions has changed over the past decade, with significant reductions occurring in the eastern part of the country, and increases in Alberta due to increasing oil sands extraction activity.

Science and policy developments in CLRTAP and beyond relating to the link between nitrogen, biodiversity and climate change

The Millenium Ecosystem Assessment (2005) has established the strong link between air pollution (especially by nitrogen) and biodiversity on the global level. Two chapters of the European Nitrogen Assessment have built on this by describing the risk and the policy response (Dise et al., in prep.) and establishing scenarios of possible future developments (Winiwarter et al. in prep.).

The exceedance of critical loads of nitrogen is used as an indicator of risk to biodiversity by the European Environment Agency (EEA 2007). Cooperation at national and European levels has explored improved relationships between critical load exceedances, nitrogen impacts and objectives set according to the EU Habitats (FFH) directive and comparable national legislation. This applies to all areas, including the Natura 2000 areas in EU Member States.

It is necessary to consider local biodiversity action plans in larger scale modelling. Strategies exist to integrate them into the European scale, e.g. via the FFH Directive and the Natura2000 network. However, the role of air pollution effects is often not explicitly taken into account even though nitrogen inputs have a large effect on biodiversity: there is room for improvement on local, national and European levels (Hicks et al., 2010; Spranger et al. 2009).

The effects of air pollution on materials, health and ecosystems are also affected by climatic conditions. Monitoring and modelling of effects has taken them into account, however, formal collaboration is in an initial phase only between air the pollution and climate change

[17] http://www.unece.org/env/documents/2007/eb/WGE/ece.eb.air.wg.1.2007.14.e.pdf

[18] http://www.unece.org/env/documents/2009/EB/wge/ece.eb.air.wg.1.2009.15.e.pdf

communities (including Intergovernmental Panel on Climate Change and UN Framework Convention on Climate Change).

CLRTAP has, among many several other science/policy developments in recent years, increased its work to link and assess nitrogen effects to climate change and biodiversity (see WGE 2009[18]). Critical loads and dynamic models have been further developed and are increasingly used as risk indicators for biodiversity loss in ecosystems (see Hettelingh et al. 2008, and in this conference volume for a recent overview).

In response to the increasing effects of anthropogenic changes of the nitrogen cycle on the environment (including air pollution and biodiversity), CLRTAP established the Task Force on Reactive Nitrogen[19] in 2007 under the Working Group on Strategies and Policies. Its tasks include the collaboration with other CLRTAP bodies to produce, inter alia:

a) a better understanding of the integrated, multi-pollutant nature of reactive nitrogen (air pollution in context of the nitrogen cycle),

b) comprehensive assessment of emissions, budgets, fluxes and effects of nitrogen;

c) a review of agricultural ammonia emissions (control techniques, good agricultural practice, etc.).

The links between air pollution with nitrogen compounds and biodiversity are being dealt with jointly by the Working Group on Effects and the Task Force on Reactive Nitrogen.

A similar development is expected concerning the relation of air pollution and climate change. Synergies between air pollution and climate change policies are increasingly being analyzed and applied to define emission reduction targets. Until recently, the focus has been to assess the co-benefits in emission reductions: According to first analyses, the implementation of climate and energy policies in combination with most technically advanced emission abatement techniques would result in the reduction of SO_2 and particulate matter emissions which are larger than needed to reach sustainable conditions with respect to health and ecosystems (e.g. critical loads) in 2050. In contrast, the resulting NO_x and ammonia emissions would not be sufficient to reach such conditions. This means that air pollution abatement policies should increasingly focus on NO_x and especially on ammonia.

While emission co-control is now in the policy focus, co-benefits, antagonisms and feedbacks concerning air pollution and climate change <u>effects</u> have until recently not been used for policy development. A recent workshop agreed which links exist and recommended their development and use in policy[20].

Challenges and outlook

The challenges and needs in capacity building on the global level relate to three fields: science, policy and communication.

1) Science

As described in Bobbink et al. (2010), de Vries et al. (2010), Dise et al. (in prep.) and documents and presentations during this conference, there exist huge knowledge gaps on nitrogen effects on ecosystems including biodiversity loss, on feedbacks with climate, and on how to model these effects. There is a clear need to improve on this especially for ecosystems outside Northwestern Europe and parts of Northern America.

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[19] http://www.clrtap-tfrn.org/

[20] http://www.naturvardsverket.se/en/In-English/Menu/GlobalM[20] http://www.clrtap-tfrn.org/enu/Conference-documentation/Intermediate-climate-policies/ , especially Working Group 2

2) Policy

The effects-based approach is one of the most important strengths of CLRTAP. The effects-oriented activities are, and will continue to be in the near future, important, particularly in evaluating the adequacy and effectiveness of emission reductions in the Gothenburg Protocol and its possible amendment, as well as to explore links between air pollution, climate change and biodiversity. CLRTAP needs to retain a strong effects-science base, coordinated by the Working Group on Effects, and to retain the focus on nitrogen effects.

Bull (in prep.) analyses options for coordinating European nitrogen policies between international treaties. Any global and/or multi-regional environmental agreement on nitrogen, be it via UN Environmental Programme (UNEP), the International Nitrogen Initiative (INI) or other routes, will most likely have a strong biodiversity effects component. To help this development, CLRTAP needs to further develop its outreach on nitrogen / biodiversity links to other regions and possibly on the global scale. This includes links to the Convention on Biological Diversity at the Convention level, and possibly in addition between the newly established Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) and the CLRTAP Working Group on Effects.

3) Communication between science, policy and the public.

Science has strongly influenced the formulation of various policies relevant to biodiversity in Europe and elsewhere. As described above, an example is the effects-based approach to air pollution abatement. The use of critical loads in that framework has been successful in summarizing scientific risk information for policymakers and the public, and has provided a quantitative estimate of the need for political action.

To continue this path for more complex issues such as feedbacks between nitrogen inputs, biodiversity and climate change, there is a strong need for good communication: shared understanding of problems and methods to solve these problems, interchange of individuals between the different arenas and, as a consequence, credibility and trust between science, policy, and the public (Grennfelt et al. 2005).

Indicators are an important communication instrument. The further development of indicators linking nitrogen pollution and biodiversity loss is dealt with by J.-P. Hettelingh et al. in this Workshop volume.

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