Acid Rain

Science and policy interactions over 50 years

Outcome of an International Symposium in Stockholm
6-7 November 2017

Report number C C327
ISBN 978-91-88787-68-2

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This report has been reviewed and approved in accordance with IVL's audited and approved management system.

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Front page photo illustrates the article in Dagens Nyheter October 24, 1967, in which Svante Odén put acid rain on the public and political agenda. (From Henning Rodhe's presentation)

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Preface

Acid rain, a key environmental issue the last decades of the 20th century, was unique in many ways. From barely known it became an international issue in just a few months. It formed the basis for one of the first international treaties on the environment – the Convention on Long-range Transboundary Air Pollution signed in 1979. It triggered an open dialogue between East and West in a period when the cold war shadowed most interactions between the two superpowers. The issue fostered also an open and positive dialogue between science and policy; scientific results were accepted and formed the basis for the policy agreements. The Convention also became a model for other environmental agreements.

For some time, particularly during the 1980s, acid rain was by many considered one of the largest environmental threats of our time. Observations of fish extinction in Scandinavian lakes and forest dieback on the European Continent were top stories in the news media. Even in North America acid rain became a political issue. Thanks to the open dialogue and collaboration between nations, the acid rain problem was successfully tackled and emissions have been reduced substantially since the peak years 1980-1990. The emissions of the key pollutant behind acid rain, sulphur dioxide, are today reduced by over 90% in most countries within the UN ECE region.

The start of acid rain as a public environmental problem can be attributed to one man and one occasion: In October 1967 the Swedish scientist Svante Odén published an article in the Swedish newspaper Dagens Nyheter, in which he alerted about a new environmental threat with possible large consequences for the ecosystems, Acid Rain. The article became the starting point of scientific and political actions that have been an area for international cooperation during 50 years.

As organisers, we wanted to manifest the 50 years of progress in tackling not only acid rain but also other international air pollution problems. We therefore invited some of those who were central in acid rain abatement to a symposium, where the main observations and lessons could be discussed. The symposium was held in Stockholm 6-7 November 2017 and was attended by approximately 70 experts, scientists and policymakers covering the 50 years of transboundary air pollution history.

This report summarizes the main outcome of the symposium. It gives a brief summary of the presentations and discussion with respect to the science-policy interactions, lessons learned and also how the experience can be used when approaching new challenges. The report is based on the talks, presentations and discussions during the two days and does not contain any references. The authors have taken some freedom in summarizing discussions in order to keep the report interesting and readable.

The symposium is further documented at *http://acidrain50years.ivl.se*

We are very grateful to the sponsors of the symposium. Without their support, it would not have been realised. We will also express our thanks to all that took part and in particular to Harald Dovland, Alec Estlander and Stefan Nyström, who in an inspiring and insightful way chaired the sessions.

Peringe Grennfelt, Anna Engleryd, Martin Forsius, Øystein Hov and Henning Rodhe

Main conclusions

Acid rain was during the last decades of the 20th century one of the largest environmental threats in Europe and North America causing severe effects to aquatic and terrestrial ecosystems.

Thanks to large scientific efforts and science-based international political agreements and the commitment to actions in Europe and North America, emissions of the acidifying substances have decreased substantially and there are signs of recovery in many ecosystems.

Acid rain was one of the first international environmental problems of significance, and its abatement required new initiatives and forms for international collaboration on environmental issues to be developed.

The discovery and the awareness-making of the problem can be attributed to one man, the Swedish scientist Svante Odén. In October 1967 he did something unconventional for a scientist, he published an alarming article in the Swedish newspaper Dagens Nyheter. Acid rain immediately became a top public story.

Thanks to a quick reaction from the Swedish government, the problem was brought to international attention within weeks and OECD decided within a couple of years to conduct a scientific investigation of the international dimension of the problem.

The Swedish case study on acid rain for the UN Conference on the Human Environment in Stockholm 1972 together with the results from the OECD investigation 1972-75 underpinned the scientific understanding and paved the road for a pan-European scientific collaboration, the European Monitoring and Evaluation Programme (EMEP), which was started in 1977.

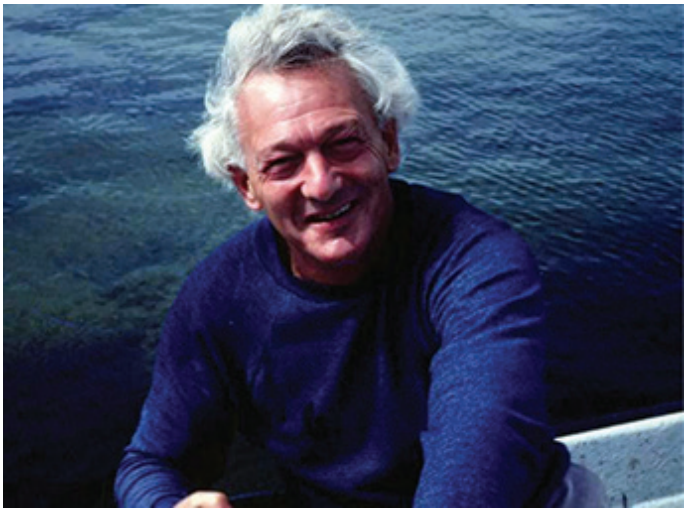
An initiative from the Soviet Union and strong engagement from the Norwegian government opened for negotiations leading to the Convention on Long-range Transboundary Air Pollution (CLRTAP) under the UN Economic Commission for Europe (UNECE).

The formation of strong international scientific communities and research programmes, such as the SNSF[1] project in Norway and the scientific bodies under the Convention, contributed to a common scientific understanding on which policy and international agreements were built.

The inclusion of scientific bodies within the Convention made it possible to continuously exchange information between the science and the policy levels. Policymakers could be updated directly from scientists, and the scientists were informed by the open questions in the policy discussions. This formed trust and legitimacy.

The establishment of science-based monitoring networks of atmospheric concentrations and deposition as well as of the effects of acid rain and other pollutants, has formed strong national communities that have built extensive national knowledge and expertise.

High emissions of air pollution, in particular sulphur dioxide, caused severe damages to ecosystems. (Photo from Jakub Hruška's presentation)



Svante Odén (Photo: Ellis Cowling).

[1]Acid precipitation – effects on forest and fish – Sur nedbørs virkning på skog og fisk.

The development of common concepts linking science and policy such as the blame matrices, critical loads and the optimised control strategies by using integrated assessment models, has significantly contributed to the acceptance of far reaching cost-effective, international control measures.

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Large scale experimental research on acid rain and its effects has played a large role for the understanding of the problem among policymakers, politicians, the public industry, and NGOs.

The strong collaboration within the framework of the Nordic scientific organisation Nordforsk and later the Nordic Council of Ministers have formed the basis for research networks and for the funding of projects directed towards the support of the Convention and later also in support of the the preparation of environmental regulations in the European Union.

Examples are the early development of methodologies for monitoring and modelling, the critical loads concept and the preparation of several protocols for emission reductions.

The continuous open and transparent interaction between the science and policy communities has formed trust. Many scientists and policymakers have interacted over extended periods of time and laws and regulation have evolved and improved as the scientific insight has become better.

Lessons learned

The Convention became a model for later conventions and protocols including the Montreal protocol on the abatement of stratospheric ozone depleting substances under the Vienna Convention, and the UNFCCC convention.

The understanding of the causes and effects of acid rain required interdisciplinary research and many scientists were committed to collaborate over disciplinary borders, sometimes at a cost of reduced career options.

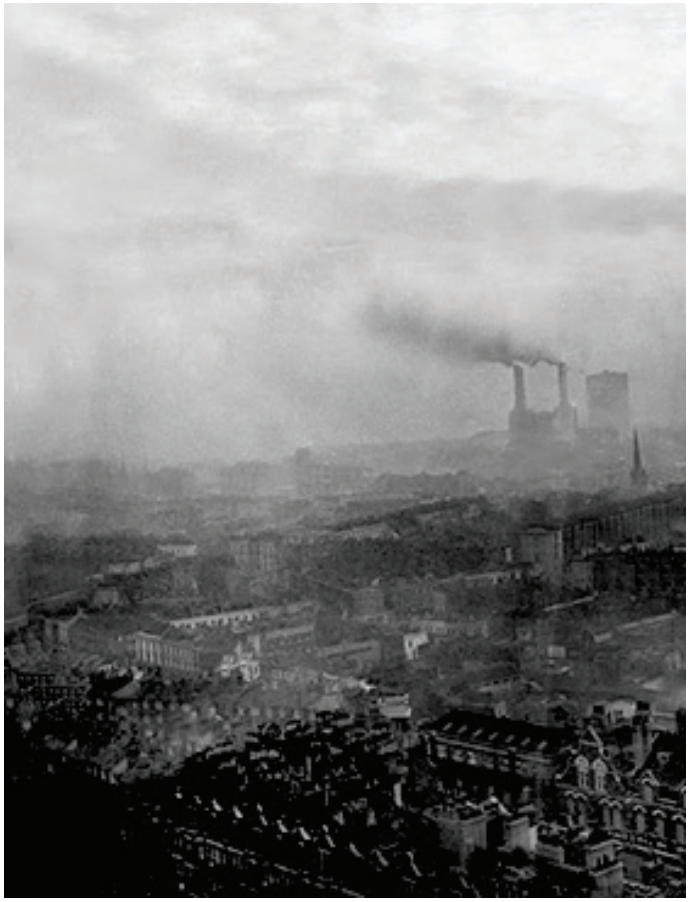
Optimised cost-effective model calculations formed a useful basis for the negotiations in contrast to pledge-based negotiations which are less efficient in problem solving.

Involvement of national experts in science, monitoring and the development of policies in the affected countries is of crucial value for the communication and understanding within countries.

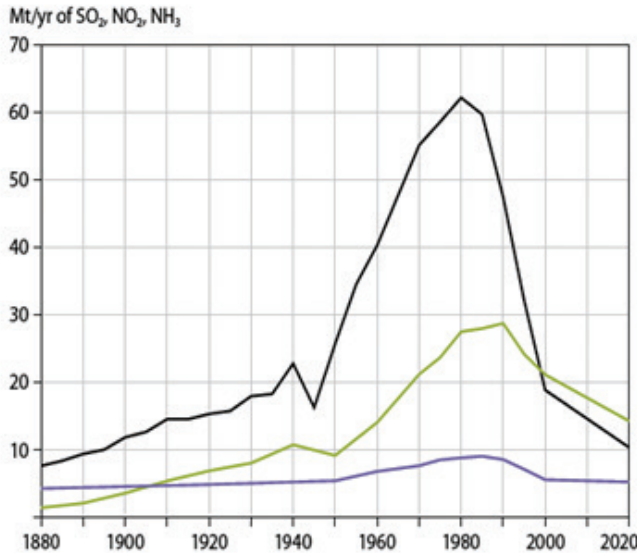
The long term commitment to develop and maintain the interactive value chain between science and policy making is crucial and a disruption anywhere in this value chain may lead to loss of competence that is hard to re-established.

The scientific support to policy has since the turn of the century continued its development to include additional aspects such as health effects, interactions with climate policies and cost-benefit considerations, while keeping the original structure of the Convention.

Many scientists have played the role of “honest brokers”



Europe was facing a different industrial landscape in the 1960’s when the acid rain problem was discovered. (Photo from from the Guardian)



European emissions of main air pollutants 1880 - 2020. After peaking around 1980 emissions of sulphur dioxide in Europe have decreased by more than 80% and are back to those around 1900. (From Anna Engleryd's presentation)

in order to strengthen the legitimacy and trust in science and policy tools.

Future challenges

Air pollution is still an important issue that needs determined actions in order to reduce global health impact in particular.

Air pollution control is more and more seen in connection with the development and actions within other areas; in particular the strong links to climate, energy, urban planning, transportation and societal needs should be considered. To reach many of the Sustainable Development Goals, air quality improvement is very important.There is a need to develop ways of operation including infrastructures in order to meet new and more advanced challenges. There is also a need to mobilise new generations of scientists that are willing to cross disciplinary boundaries and devote themselves to thematic issues such as those typical for environmental problems.

Scientists need to engage on the policy arena as experts in order to understand the policy issues and act upon them as experts so that science-based policy evolves. To achieve and maintain trust is crucial in all future environmental research and its communication to policy makers.

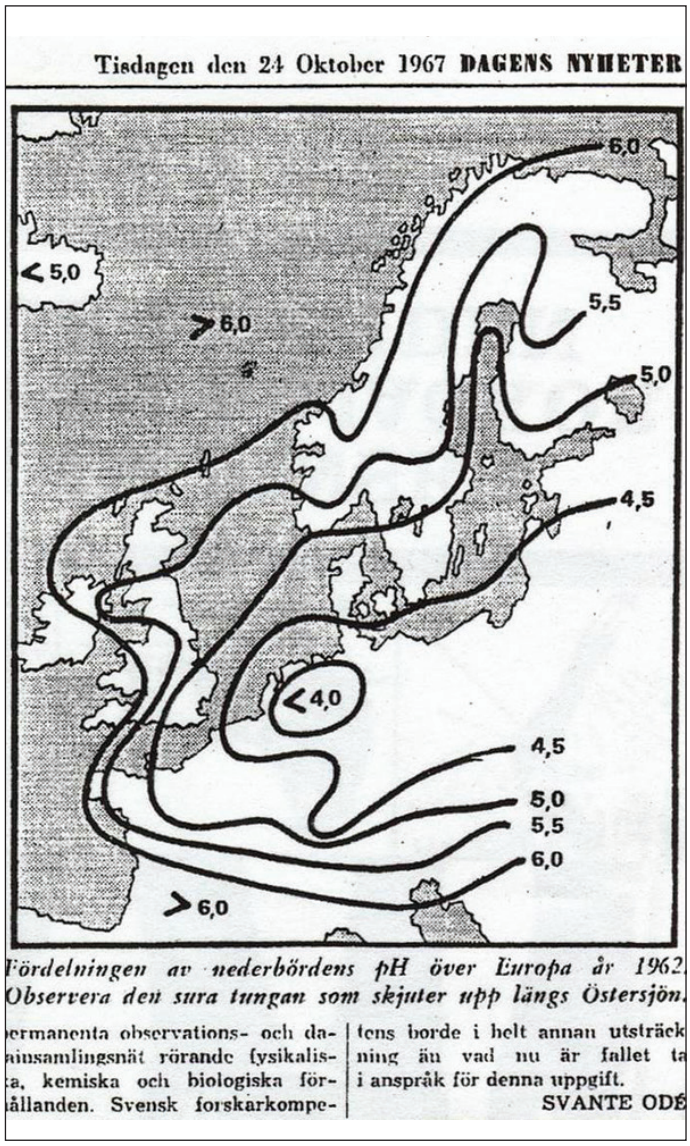
What was learnt with respect to abatement strategies and measures of acid rain and other pollutants within the UN ECE region should be shared with those countries in other parts of the world that are experiencing similar pollution problems.

Photo: NIVA (from Brit Lisa Skjelkvåles presentation)

Main report

The early discoveries

In the first talk at the symposium Lennart Granat[2] presented the early discoveries by Svante Odén and how his findings were brought to public attention through an article in the Swedish newspaper Dagens Nyheter on 24 October, 1967. In the article Svante Odén presented a completely new phenomenon threatening the European ecosystems with major international and economic consequences. The discovery received immediate attention by the Swedish government and already in December that year it was brought up in the OECD. Odén's discoveries were to a large extent based on the regional precipitation networks that were set up in Sweden and Europe. It all began with a Swedish precipitation chemistry project initiated in 1947 by Hans Egner. In 1954 the European Air Chemistry Network (EACN) was initiated by Rossby, Egnér and Eriksson. Data from these networks formed the basis for Odén's observations on the ongoing acidification of precipitation.


Tisdagen den 24 Oktober 1967 DAGENS NYHETER

Fördelningen av nederbördens pH över Europa år 1962. Observera den sura tungan som skjuter upp längs Östersjön.

ermanenta observations- och da- | tens borde i helt annan utsträck
insamlingsnät rörande fysikalis- | ning än vad nu är fallet ta
a, kemiska och biologiska för- | i anspråk för denna uppgift.
hållanden. Svensk forskarkompe- | SVANTE ODÉ

Illustration in the iconic article in Dagens Nyheter showing pH values in precipitation 1962. Data from the European Air Chemistry Network. (From Henning Rodhe's presentation)

The effects of acid rain were, however, known before 1967. Observations were made in particular in Norway, where salmon catches had decreased substantially over the previous decades. Brit Lisa Skjelkvåle mentioned in her talk that Professor Knut Dahl already in 1927 hypothesized that acidification of surface waters could be a factor of importance for the extinction of fish. Alf Dannevig wrote in 1959: "The acidity of a lake is dependent on the acidity of the rain water and the contributions from the soil". Later studies showed that the salmon catch decreased as early as in the beginning of the 20th century.

Long range transport of air pollution was also envisaged long before and Lennart Granat cited Henrik Ibsen's play "Fire" (Brand), indicating that people were aware of transboundary air pollution even in the 19th century:

"Worse times, worse sins through the night of future flashes of Britain's suffocating coal dust is slowly descending over the countryside soiling all that is green strangling all that strives to grow creeping low and mixed with poison stealing sun and light from the valley pelting down as rain of ashes."

An important contribution to the understanding of the problem's geographical extent was made by Cyrill Brosset, who showed a substantial transport of air pollution from the European continent to Scandinavia. Göran Persson gave an insight in how the acid rain issue was brought to the international agenda. A few weeks after the Odén's publication in Dagens Nyheter, the minister of industry brought the issue to the OECD but it didn't receive any attention at that time. Swedish delegates did some more attempts without success. Göran Persson then presented Oden's findings for OECD's Air Pollution Management Committee.

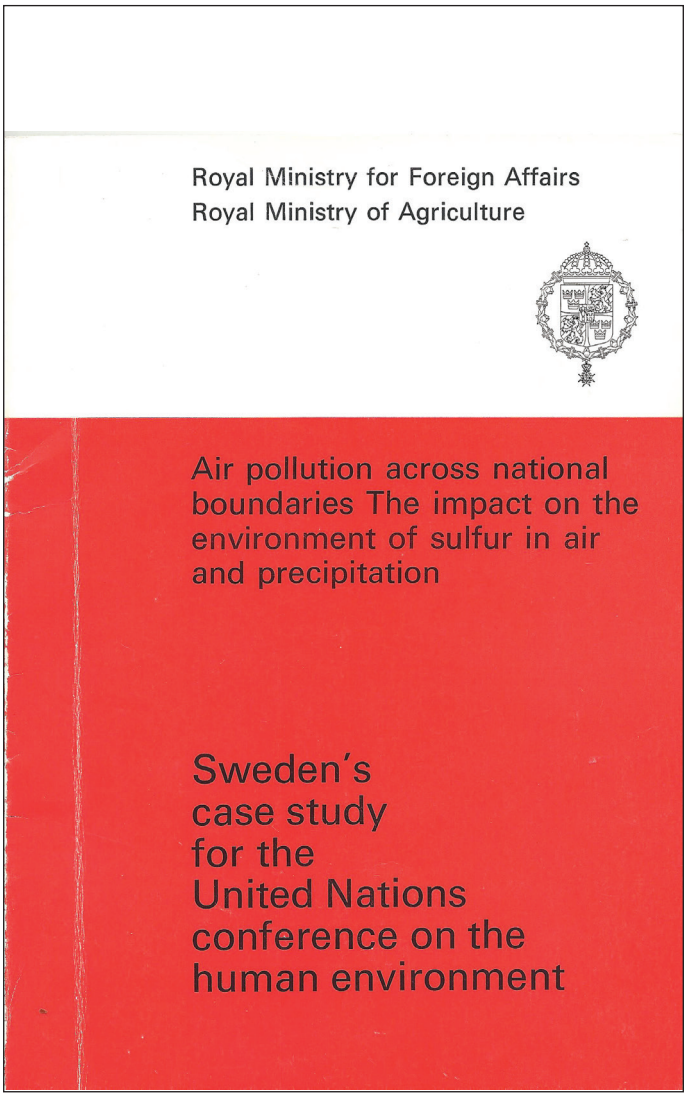
Even here the message was met by scepticism and the common opinion among the members in the committee

[2]The first presentation at the symposium was prepared by Henning Rodhe. Due to an acute illness he was not able to give the presentation. Instead, it was given by his long-standing colleague Lennart Granat.

was that sulphur dioxide was a local problem which easily could be solved by tall stacks. It wasn't until Göran Persson felt he was going to loose the case he "played his last card" and pointed to the observations of intercontinental transport of radioactivity from the Chinese nuclear bomb experiments, the opinion changed and the meeting agreed that acid rain might be an issue to look further into.

The Swedish case study

The Swedish government had taken the acid rain problem to its heart and saw an opportunity to present this new air pollution problem as a key issue at the UN Conference on the Human Environment in Stockholm 1972. Two years after Odén's article the Swedish government therefore decided to prepare a so called case study as a contribution to the conference. Bert Bolin at the Stockholm University was the natural choice for chairing the project. The report was prepared by eight scientists and experts, who spent almost two years. It included original research in the fields of meteorology, atmospheric and surface water chemistry, corrosion, health effects, forestry and environmental economy. Henning Rodhe was one of the scientists and from his presentation we got a direct insight in the work with the report and the novelty in many of the approaches.



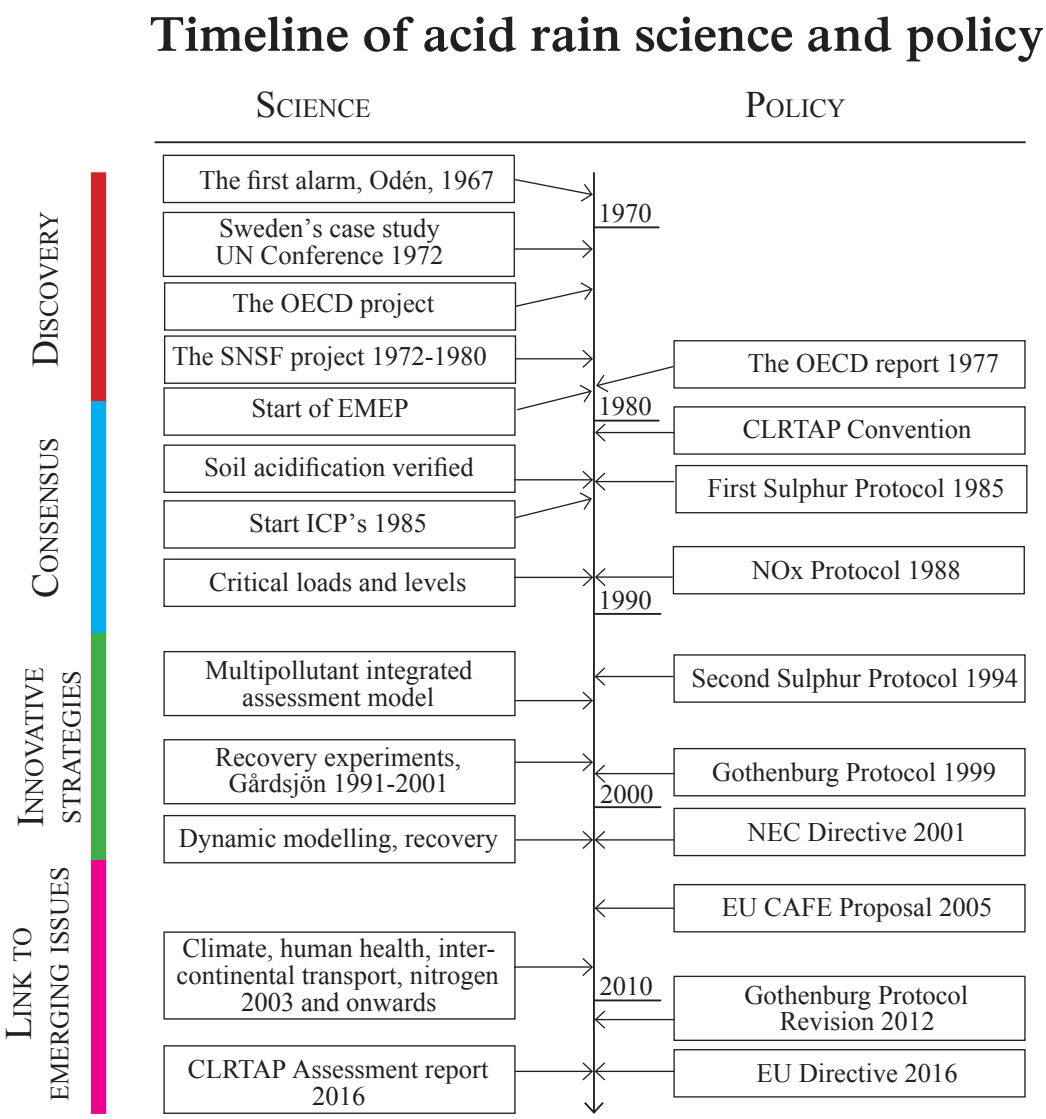
The report resulted in a number of conclusions, including an estimate of the relative contributions to the sulphur deposition in Sweden from domestic and foreign emissions; that the sulphur emissions resulted in an excess mortality in Sweden of 600-800 per year; that if present trends in emissions continue half of the Swedish lakes and rivers would reach a critical pH level within 50 years. The report also included the first system analysis of the acid rain problem including scenarios and estimated costs for control. Certain aspects of the report received criticism but the case study was well received by the UN conference and its final report explicitly mentioned regional pollution (§85) with a citation of the Swedish study.

The OECD project

The Nordic initiative in the OECD resulted in a decision to set up a collaborative project to investigate the nature and magnitude of the transboundary transport in Western Europe of emitted sulphur dioxide. Peringe Grennfelt mentioned in his talk that Nordic collaboration played a crucial role in the development of the project. Scientists and institutions from Norway, Sweden, Denmark and Finland were asked to plan and develop methodologies for the investigation. This work took place under the umbrella of Nordforsk (a Nordic organisation on scientific research) and in April 1970 an expert group was established.

The group became central for the development and implementation of the project and the Norwegian Institute for Air Research (NILU) offered through its director Brynulf Ottar to coordinate the project. It included basic emission inventories, measurements of atmospheric concentrations and deposition of acidifying species in eleven West European countries and model development and application for the assessment of the transport.

The main conclusion from the OECD project, published in 1977, was that "Sulphur compounds do travel long distances in the atmosphere and the air quality in any European country is measurably affected by emissions from other European countries". Even if there still were hesitations about the magnitude of the transport, the



Timeline of acid rain science and policy in Europe. (From Peringe Grennfelt's presentation)

common opinion was that transboundary transport of air pollution is an issue that needs collaboration over national borders.

Several participants at the symposium pointed to the value of the OECD project. One of them, Arne Tollan, claimed that the project ended the controversy on whether the transboundary transport really took place and that it paved the way for CLRTAP.

Early research initiatives in Norway

Lars Walløe took a Norwegian view of the acid rain problem. In his talk he mentioned that when the alarm came in the late 1960s, Svante Odén received strong support from Professor Eilif Dahl at the Norwegian Agricultural University, who invited Odén to Norway and together they gave lectures to Norwegian forest owners and representatives of the wood-processing industry. At the same time the Norwegian public expressed concern about what seemed to be a strong decline in the abundance of fish in rivers and lakes in southern Norway.

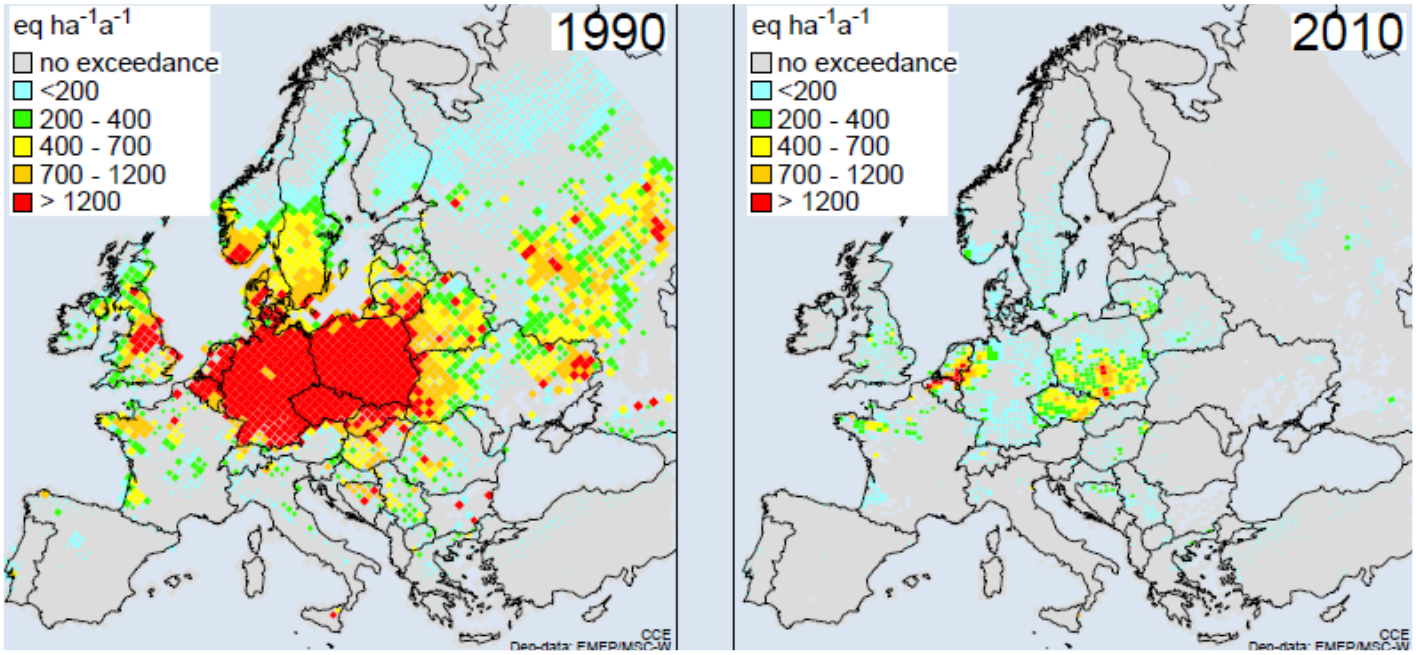
Björn Rosseland mentioned that the analysis of the effects of acid rain was helped by the very good data on fish catches, thanks to the careful data collection by Norwegian lake owners. They had followed fish catches for many years and could present data that could be aligned with water and precipitation chemistry data. As a result of the observations and concerns the Norwegian technical-industrial and the agricultural

research councils in 1972 funded a research programme with the title "The effects of air pollution on soil, vegetation and water". The Ministry of Environment in Norway decided to participate in the funding of the research programme on the condition that the possible decline in fresh water fish was also investigated. The funding increased considerably and the programme changed its title to "Acid precipitation – effects on forest and fish" (SNSF). The programme was planned to last for three years (1973-75) and to end with an international conference in 1976. Many of the researchers working in the programme were junior scientists attached to applied research institutions or the agricultural university, most of them without a doctoral degree.

When the first results from the SNSF programme were published in late 1975 and early 1976, indicating effects of acid precipitation both on forest and fish, the programme received strong and serious criticism from a number of professors from the science faculty at the University of Oslo, foremost among them Ivan Rosenqvist, professor in geology. The criticism was intensified by the representatives of foreign governments during the international conference in June 1976. Rosenqvist was persuaded to present his arguments in writing, which he did the following autumn, and the SNSF programme responded by a report mainly written by Eilif Dahl. Lars Walløe told that he was asked by Gro Harlem Brundtland, who was the minister of environment from 1974, to be the new chair of the steering committee with free hands to reorganise the programme. During the next few years a number of different small scale field experiments and computer simulation models were set up to investigate possible effects.

The final results of the SNSF project were presented at an international conference in March 1980. The conclusions were that long transport of sulphur deposition had caused an acidification of surface water in southern Norway with a serious die off of fresh water fish populations (salmon and trout) as a main consequence. The project did, however, not find any effects on forest growth in Norwegian ecosystems.

Scientists and politicians in UK did not accept the results on fish deaths. When the results were presented in a meeting in the Royal Society in 1980, one senior academy member said: "Every important result obtained by a non-British scientist, must be confirmed." This 'confirmation' happened according to Lars Walløe, during the British-Swedish-Norwegian research programme "The Surface Waters Acidification Programme" (1984-90) The programme was funded by the electricity and coal industry in the UK and organized through the Science Academies in the UK, Norway and Sweden. Many new details were explored and studied, but the main conclusions from the SNSF programme did not change.



Accumulated average exceedance of critical loads for acidification 1990 and 2010. (From Anna Engleryd's presentation)

The birth of a Convention

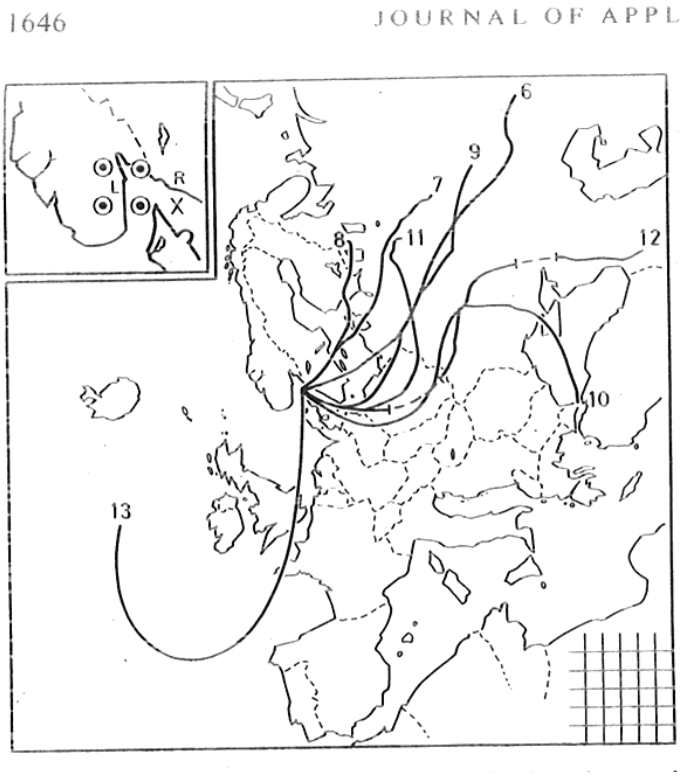
Based on the outcome of the UN Conference in 1972 and an initiative taken within the Organization for Security and Co-operation in Europe (OSCE), in particular by the Soviet Union, international cooperation on air pollution was brought up as an issue for collaboration between East and West. The western countries were skeptical but thanks to Gro Harlem Brundtland, at that time Norwegian minister of environment, a bridge was formed between East and West which ended up in the establishment of the Convention on Long-range Transboundary Air Pollution (CLRTAP) signed in 1979. Jan Thompson, who took part in the discussions in Moscow between Brundtland and the Soviet representative Valentin Sokolovski, made clear that any international agreement at that time needed to have the Soviet Union on board, otherwise no other countries from the East would participate.
An additional aspect was that the OECD project had shown that West Europe received significant amount of pollutants from the East.

The OECD project also formed the basis for a pan-European monitoring network – the European Monitoring and Evaluation Programme (EMEP) starting in 1977. The EMEP monitoring network was a central part of the Convention already from the beginning, contributing strongly to the scientific platform and credibility underpinning the policy process and agreements.

Lars Björkbom mentioned that there were other issues than strictly environmental ones, drove the measures to reduce air pollution. One example was Margaret Thatcher's fight to reduce the political power of coal miners in the mid-1980s. The environmental request to reduce air pollution emissions weighed in that battle on the government's side. Another issue, leading to significant emission reductions of sulphur dioxide was the energy crisis in the 1970s, which changed the energy policies in many countries.

Beginning of the 1980s: Threats to forests

In his presentation, Karl Josef Meiwes from Germany spoke about how the alarm regarding forest damages due to air pollution in Central Europe around 1980 raised the interest in air pollution. In 1980 Bernhard Ulrich and co-workers pointed to the threat from atmospheric deposition and in particular that of sulphur to European forests. From his long term experiments in the Solling area he showed how the high deposition of atmospheric



Back calculations of the origin of air pollution episodes were important for the early understanding and modelling of air pollution transport in Europe. (From Anton Eliassen's presentation)

pollutants had changed the soil chemistry. Ulrich pointed in particular to the links between sulphur deposition and the release of inorganic aluminum. His alarming reports became an issue not only for Germany but for Europe as a whole and also for North America. Meiwes described how the alarming reports drove the rapid policy change in Germany.

During this period media began to talk about the "Black Triangle", consisting of the border areas between Poland, East Germany and Czechoslovakia, in order to describe the most polluted areas in Europe. The Black Triangle with photos of dying forests became a sign that went through all media in Europe. Jakub Hruska gave a picture of the situation in the Czech Republic. While Germany acted almost immediately on the alarms, the progress in emission control in Eastern Europe was very slow during the 1980s. Emission reductions did not take place until after the break-down of the communist regimes in the East. In the presentation he showed how the dying forests now were replaced by young vital forest stands.

The increasing interest in regional air pollution also paved the road for the first international agreement under the CLRTAP. As a start countries with a large interest in taking action formed a "30 % club". When Germany stated that air pollution could cause forest damage, it led not only to ratification by Germany, but also by a number of other countries. The Helsinki protocol in 1985, including a commitment of 30% reduction in emissions, was also a breakthrough.

The protocol was signed by a large number of countries from both East and West. But Bedrich Moldan argued that when Czechoslovakia signed the protocol it was clear that it was completely impossible to reduce the emissions with 30% as stipulated in the protocol. The attitude of the communist regimes to environmental pollution was according to him a complete denial: "We are the best of regimes."

Bedrich Moldan was at this time involved in the ecological section of the Czech Academy of Science. A report was put together to the premier minister in 1983, who was concerned about the environment. The book was picked by Charta 77 and through the international press and the Radio of free Europe it was brought to the knowledge of the Czech public. The issue now became quite well known. Among the activities was a symposium in 1987 organised under the name of GEOMON Geochemical Monitoring in Representative Basins, where scientists from several countries were able to see the massive forest decline in Ertzgebirge and other areas.

In 1989 the Iron Curtain fell. Before that there were several demonstrations in the most polluted area, the Triplice region, complaining about the bad air situation. Immediately after 1989 actions were taken and in ten years the emissions of sulphur dioxide were reduced by almost 90%.

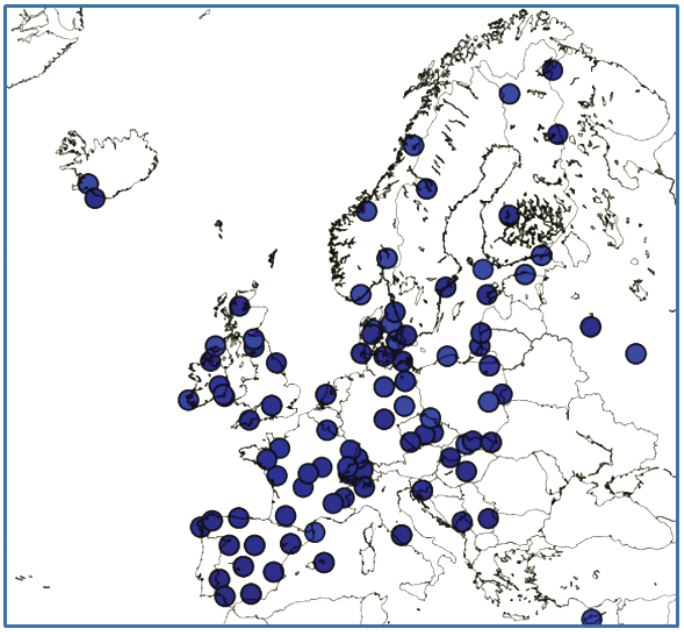
David Fowler pointed out the big change between 1980 and 1985 regarding the interest in acid rain and transboundary air pollution. The outcome of the SNSF project provided as shown at the Sandefjord conference in 1980, clear evidence of the links between acid rain and lake acidification, but a lot of uncertainties regarding the effects on forests. At the following acid rain conference in Muskoka 1985 many observations of forest decline were reported. This was instrumental for driving the science and policy forward. Even if the links between acid rain and forest damage were not fully understood, the observations became a strong driver for actions.

Lars Walløe added that we often forget how aggressive the debate sometimes was, both among scientists and politicians, but also between Norway and Sweden on the one hand and UK on the other.

Acid rain in North America

In his presentation, Ellis Cowling pointed out how the acid rain problem in North America mainly developed in parallel with the European. As in Europe, it became a key air pollution problem from the early 1970s and onwards.

It started with a visit to Sweden by Ellis Cowling, who was introduced to Svante Odén and his findings. Cowling invited Odén to North America where he gave several lectures in Canada and the US that stimulated the US Forest Service to join many other organizations in sponsoring "The First International Symposium on Acid Precipitation and the Forest Ecosystem" at Ohio State University in 1975. At the conference it was shown that acid rain caused substantial effects to lake ecosystems, particularly in the North East of the United States and adiacent areas in Canada.



EMEP sites 2015 (SO4). (From Kjetil Tørseth's presentation)

The Ohio conference became the starting point for establishing precipitation networks. Canada began monitoring in 1976 and the US in 1978. The networks grew over the coming years and monitoring is still ongoing in a similar way as in Europe. The two networks played an important role for the assessment of the transboundary transport between the US and Canada, which during the late 1970s and 1980s became a controversial issue between the two countries.

In the US a ten year extensive research program, the National Acid Precipitation Assessment Program (NAPAP) was set up. When the results were presented around 1990, it opened up both for far reaching emission control and for a long term agreement on acid precipitation between the two North American countries; the Canada-United States Air Quality Agreement. The agreement has later been updated to include ozone and particulate matter (PM).

Ellis Cowling also showed the success of the agreements between Canada and the United States: the SO2 emissions in Canada have decreased by almost 70% and the US utility emissions by 90%. For NOx utility emissions have been reduced by more than 80% in both countries.

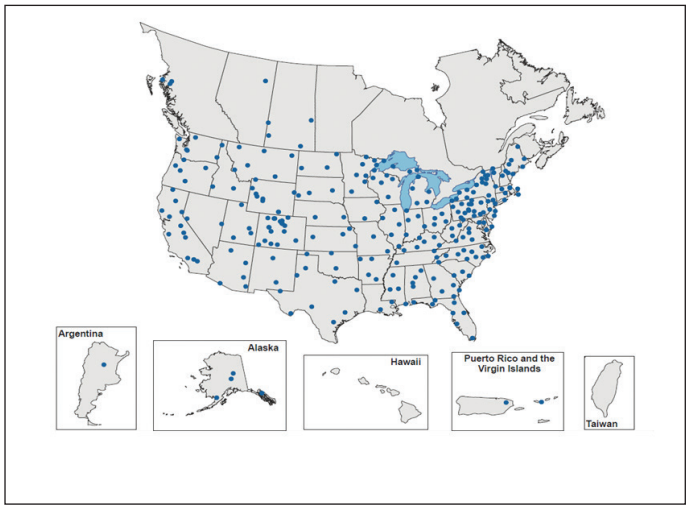
Atmosphere and ecosystems: Monitoring and modelling

Monitoring of atmospheric concentrations, deposition and ecosystem effects have been a key for understanding the causes, impact and trends in acid rain, both in Europe and North America. Kjetil Tørseth showed in his presentation an insight in how the EMEP network was established as a continuation and expansion of the OECD project and how it has developed over the 40 years since 1977. He pointed in particular to the importance of coordination and quality assurance through standardised methods, training and intercalibrations. He also showed the value of having easily accessible databases. The network has been a model for a number of other monitoring networks related to other conventions and purposes.

The EMEP monitoring programme has developed from simple inorganic measurements focusing on sulphur in the 1970s and "new" substances such as ozone and nitrogen compounds to advanced stations where the physicochemical behaviour of the atmosphere is monitored in a wide sense. The data are today widely used for the understanding of atmospheric processes and as a basis for modelling. Kjetil Tørseth concluded that the long term commitment both from the participating countries and the EMEP centres have been key factors for the success.

The numerical modelling of atmospheric pollution is also a long term commitment. The atmospheric chemistry models have helped us to understand the nature of transboundary transport but also to make budget estimates of the exchange of pollutants over Europe. Henning Rodhe showed (through his stand-in Lennart Granat) the early budget estimates of sulphur import from a Swedish perspective. The OECD project also included dispersion and deposition modelling with a first estimate of a (west) European budget. The early methodologies and how these were used to establish so called blame matrices were described by Anton Eliassen, but the large achievements in modelling have developed from 1980s and onwards with the Meteorological Synthesizing Centre West at the Norwegian Meteorological Institute in the lead.

The value of ecosystems monitoring was highlighted in the presentations by Isaura Rabago and Brit Lisa Skjelkvåle. Under the CLRTAP a number of monitoring and investigation programmes were set up in the middle of 1980s focusing on different aspects of the effects of transboundary air pollution. They were organised in so called Integrated Cooperative Programmes (ICPs) for forests, waters, vegetation (primarily ozone), material and integrated monitoring. The programmes have been of great importance for a general understanding of the magnitude and geographical distribution of the effects and for showing how reductions in emissions have



NADP National Trends Network Sites in 2017. (From Ellis Cowling's presentation)

influenced ecosystems. Ecosystem monitoring has also become important for the development and verification of ecosystem models.

Critical loads

One of the most important concepts to link science and policy in acid rain was "critical loads". The concept and its importance for the development of cost-effective strategies were mentioned several times at the symposium.

The concept was first discussed in 1982 but it was on the initiative of Jan Nilsson that it was taken to the scientific and political communities as a unifying idea upon which international control strategies and long term commitments could be built. Jan Nilsson gave a lively description of his contribution. "During the years 1986-88 I became Mr Critical Load." It all started with the requests from both industry and negotiators to have a sounder base for emission control. The concept was first met by skepticism, not least from scientists, but after a couple of workshops, the interest turned around and the concept became a key for the international negotiations. When it was included in the plans for the next rounds of sulphur and nitrogen protocols in 1988 it changed the way the convention operated.

The ideas behind and the application of the critical loads concept was further described in a presentation by Max Posch from RIVM. Being involved in the implementation of critical loads for more than 25 years he gave a lecture on how the concept was taken from the original idea to application. A particular important step was the preparation of mapping manuals, which were used by the countries to develop their own critical loads' maps. The application of the critical loads concept built in this way its own community within the CLRTAP in parallel with the ICPs.

A couple of general conclusions were drawn from the presentations and discussions regarding monitoring and critical loads' mapping.

- The recognition of the value of science-based policy making helped forming an active base in science and research in every country, of crucial value for the communication and understanding within countries and in the emergence of political will to support and implement abatement measures.
- The long term commitment from countries has been crucial and any stop in activity may lead to a loss of competence that hardly can be re-established.

Integrated assessment modelling and more advanced protocols

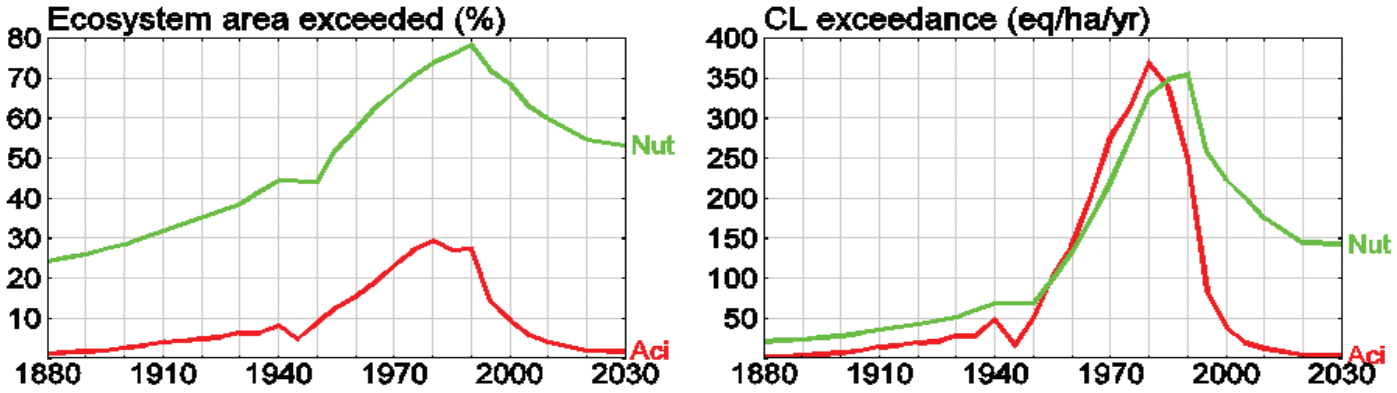
The transboundary problem with acid rain was identified as an opportunity for systems analysis and at the International Institute for Applied Systems Analysis at Laxenburg, Austria, a project was set up in 1983. It was led by Leen Hordijk who formulated a conceptual model for the analysis of the interactions between emissions and their control and the effects on ecosystems.

When the critical loads became a basis for further protocols, the Integrated assessment models (IAMs) received a basis for analysing effects to ecosystems, that fitted the idea of cost-effective control strategies and the critical loads was used for the first time in the second sulphur protocol from 1994.

The next step in the development of control strategies was to revise or develop a new protocol for nitrogen oxides. In his presentation, Peringe Grennfelt mentioned a workshop held in Oslo in 1992 which brought up the issue of what a second NOx protocol should look like. Together with Øystein Hov he showed that the concept could not be used for nitrogen oxides in the same way as for sulphur for acid deposition. Instead they proposed an integrated approach that took both several effects and several compounds into account simultaneously. The scientific knowledge for all the steps in the calculations was in place for an integrated assessment approach. After the decision in the policy bodies of the convention, the Task Force on Integrated Assessment Modelling and IIASA were asked to develop a model approach along these lines for the next protocol. An intense effort at IIASA made it possible to further develop the model and deliver optimised cost-effective solutions that simultaneously took into account the effects of acidic deposition, nitrogen deposition and ozone. The calculations became then the basis for the Gothenburg protocol that was signed in 1999.

Air pollution today and new challenges

Even though we have achieved large reductions in emissions and seen many positive signs regarding ecosystem effects, there are still remaining problems. The situation is, however, different to that 30-40 years ago. Concentrations and deposition of sulphur have decreased substantially but we are still facing the historical impact that delays the recovery of acidification. The outcome of control measures has therefore become a key issue. We all want to know that we have got value for the measures



Trends of exceedances in critical loads for acidity (red) and nutrient nitrogen (green) since 1880. (From Maximilian Posch's presentation).

taken. Brit Lisa Skjelkvåle showed in her presentation that ecosystems are recovering and some key species are returning, e.g. salmon to the Norwegian rivers.

The outcome of decreasing emissions has also been a topic for large research experiments such as the catchment experiments in Norway and Sweden. Filip Moldan showed in his presentation how the roof experiment at Lake Gårdsjön helped us to understand the dynamics in response to reduced sulphur emissions. Another experiment showed how the ecosystems dynamics were influenced by increased nitrogen deposition in a forested catchment. These and similar experiments have served as inputs for model developments and verifications, an issue that was further elaborated by Julian Aherne. In his presentation he showed that today we have models that can describe the relation between sulphur deposition and soil chemistry but that there are still problems in understanding the dynamics related to nitrogen deposition.

In parallel with the reduced emissions of sulphur and signs of recovery of acidification, other problems have emerged. Christer Ågren pointed to the shift in interest that occurred at the end of last century when health effects became the key element for air pollution control. The health aspects of air pollution were followed up with a presentation by Elisabet Lindgren. She pointed in particular to the importance of particulates for the human health. She also brought up the relationship between acid rain and human health. She showed that acid rain may cause increased concentrations of inorganic aluminum in drinking water posing a health risk. This is particularly important for those having private wells.

In her presentation, Laurence Rouil pointed out that concentrations of particulate matter (PM) and nitrogen dioxide in urban areas are key topics for emission control, both for the CLRTAP and the EU. She mentioned that we have to consider that the hemispheric background of ozone have not changed over the last decades. This means, according to her, that future international work on transboundary air pollution needs to change its interest to cover different scales in conjunction; local, regional, global. In urban air pollution episodes with high PM concentrations more than 50% are caused by international transport of air pollution. Local authorities are often not aware of this and don't understand that the problems can't be solved only by local actions. For ozone and the contribution from the hemispheric background it is important to include the main precursor, methane, in future control strategies.

Future air pollution strategies therefore need different approaches. Laurence Rouil also asserted that it is important to take sectoral approaches into account, such as introduction of electric cars, agricultural policies to reduce ammonia emission, public transport policies, shipping etc. The very close link between air pollution, urban planning and climate is also an issue to consider in the future.

Even though the interest and priorities have moved from ecosystems to human health, many ecosystems are still under threat. Both Brit Lisa Skjelkvåle and Isaura Rabago pointed to the biodiversity loss due to nitrogen deposition and the needs to further reduce nitrogen emissions, in particular from agriculture. David Fowler gave a review of the many aspects of the nitrogen problem, mentioning

that there have been substantial reductions in NOx emissions. For ammonia, there is much less progress and here we are facing a problem that needs wider actions than technical solutions; we need to consider its relation to our food consumption and choice in a world with a growing population.

The future direction of work within the CLRTAP was the topic of Anna Engleryd's presentation. She mentioned that new priorities are about to be set based on an assessment report that was prepared in 2016[3]. She pointed in particular to the importance that all countries under the Convention, in particular those in the EECCA region, ratify actual protocols.

A new challenge that has been taken up by CLRTAP, is how to go global. Air pollution is a universal problem and the experience and technical skills from CLRTAP could be of major interest for other regions. The UN Environment and its next assembly meeting UNEA 3 may give directions for this further work.

Carsten Larsen from the European Commission described the work on air pollution within the European Union. The EU policy on air pollution is built on science and the policy has relied to a large extent on the work within the CLRTAP. He also pointed to the fact that since the end of last century health impact has come up as a main driver for air pollution control in Europe. Another new aspect is the economic scrutiny of environmental policies. This is not unique for air pollution, it applies to all environmental policies and the EU system requires expensive impact assessments. The air pollution area has however been quite well prepared. Even if such studies are valuable they have taken a lot of resources and they have sometimes been used as a reason for not taking action.

One of the challenges for the EU and the CLRTAP is how to use cost benefit analysis. One outcome of those analyses is that the benefits of actions are almost always outweighing the costs for taking action but this argument is often of no or limited value when it comes to the political level. This was underlined both of Carsten Larsen and Christer Ågren.

Over the last ten years the links between air pollution and climate change have been an issue of increased interest. In many cases the sources are the same and there are large co-benefits (and some tradeoffs) in handling them together. One particular aspect that has received large interest is the possibility to reduce short term temperature increase through control measures directed towards atmospheric pollutants that contribute to warming the atmosphere, in particular black carbon and methane (for methane both by itself but also as a contributor to tropospheric ozone). The opposite effect, i.e. cooling of the atmosphere, is caused by small secondary aerosols, e.g. sulphate particles.

The roof at Lake Gårdsjön. Photo: Filip Moldan

[3]Towards Cleaner Air: https://www.unece.org/index.php?id=42861

Annica Ekman showed in her presentation how the sulphur emissions in Europe over the last 30-40 years has masked the warming of Arctic during several decades and that now, when these emissions have decreased, they have contributed to the rapid warming of the Arctic. She showed that our understanding of the links between air pollution and its influence on climate have improved rapidly during the last years, in particular that we now understand that the transport of heat is as important as the transport of the pollutants themselves for the climate response of changes in the radiative forcing.

Christer Ågren underlined the large change in the way international air pollution science and policy is working today. In the beginning it was all about the environment and the effects on ecosystem. The major change started in the mid-1990s. Then the economists also joined and cost-effectiveness became the main tool. Today it has changed further and now it is cost-benefit. In addition, nobody is today questioning that critical loads and WHO health guidelines should be the basis for control measures. The question is instead when and by whom the control should be undertaken. Control strategies have also become a mixture of control measures between countries and sectors and East and West.

Xiaobin Xu gave a presentation on the development of the acid rain problem in China and other East Asian countries from the first observations around 1980 and onwards. He showed that China has experienced severe acid rain problems in the last two or three decades. The sulphur emissions as well as the acidity of rain peaked around 2006 and have since then decreased due to a series of control policies and measures. He also pointed to the importance of the Acid Deposition Monitoring Network in East Asia (EANET) that has collected data on concentrations and deposition for almost 20 years. Even if the trends have turned downwards, there will be large needs for further emission control to reduce acid deposition. Xiaobin Xu also noted that the largest air pollution problems today are connected to health and that improvements in acid deposition should rather be seen as a co-benefit of measures to protect health.

Lars Nordberg complemented the presentation with mentioning the Malé Declaration, which also was initiated at the end of 1990s. It has tried to copy from the example of CLRTAP. Even if the achievements in terms of policy are limited, the network is still in operation.

Markus Amann added that China, India and other fast-growing economies are facing large problems with the air pollution and its effects on human health. Unfortunately scientists are sometimes coming up with very partial solutions which are not coordinated and not taking into account the necessary holistic view on the problem. He mentioned that even in a city with a population of 17 million inhabitants, 60% of the exposure is coming from outside and in this situation it does not help to control the 40%.

Reasons for success and lessons learned

One of the most important objectives of the symposium was to extract and discuss why the acid rain problem became was in many ways solved successfully and what we have learned from the 50 years of progress in science and policy and their interrelations. In this part of the report the focus is on the comments made during the symposium.

Göran Persson mentioned in his presentation three circumstances that helped the success from the very beginning:

1. Bringing the issue to the international level. The rapid introduction of the problem in international fora, in particular the OECD, provided attention to the problem.
2. Building alliances. First with the Nordic countries, then through the so called 30% club.
3. The scientific back-up. In particular the role of the Norwegian Meteorological Institute and the Norwegian Institute for Air Research, which then formed two of the key EMEP centres.

Karin Bäckstrand gave a talk on the acid rain issue from a political science perspective. She pointed to the success within the field of transboundary air pollution in comparison to many other areas, where there have been limited success and even failures. She meant that in social scientific terms air pollution diplomacy under the Convention has been pioneering in tackling global collective action problems, promoting public good of clean air and preventing free-riding. The success also includes innovative institutional design of the science – policy interplay, in multilateral environmental diplomacy and not the least, development of science-based concepts, in particular the critical loads, which have served as a foundation for transnational air pollution agreements.

Many of the scientists within political science have also pointed to the importance of a scientific framework and networks.

Karin Bäckstrand pointed further to the importance of leadership. Sweden, Norway and Canada were first movers. Another issue of importance was the geopolitical context and the triggering events that formed windows of opportunity. She also mentioned the importance of the innovation of an interface between science and policy through integrated assessment models.

She also mentioned that the framings of the convention have changed over time and been adapted to new situations, going from an initial framing around acidification, which subsequently extended to eutrophication, human health, materials, crops, biological diversity and links to climate. Work in political science, international relations science and technology studies (STS) point all to the importance of the framing of science and importance of consensual knowledge. Another factor is the building of networks. The strong networks of scientists and policymakers pushed the politics. The whole field of international diplomacy during these four decades has built on incremental development forming more and more advanced protocols for the steps to be taken to cut emissions.

Jan Thompson referred to the talk by Karin Bäckstrand and her description of the convention and its way of working as an "innovative institutional design" with a division of labour between national institutes, coordinating centres and formal working groups. All of this has, according to him, formed a momentum and has proven to be innovative and effective. While science always has been a necessary precondition, it has, however, not always been sufficient. He also claimed the importance of trust, which often has developed into friendship.

Karin Bäckstrand also pointed to the well-known gap between science and policy and the problems in filling this gap. Ideally we want to see science speaking their findings to the political side and that politicians should take rational decisions. But there are many obstacles in this process. Policymakers are informed by many others and sometimes policymakers exploit scientific uncertainty in order to take no action, and - finally – scientists are not unbiased. A more realistic way of looking at the problem is, according to her, a model that she called the "garbage can model". She also pointed strongly to the important role scientists can play as brokers.

What science can and cannot provide at a certain point has often been a point of discussion. It has often led us to solutions, where scientists involved in the science-policy dialogue have shown the actual knowledge with all its uncertainties. Within the acid rain community policymakers have instead been confronted with openness and transparency, which have given them enough insight to understand to what extent the underlying science is robust despite the uncertainties. Øystein Hov pointed to the value of understanding users' different ways of thinking, with respect for both societal analysis and knowledge basis. We have seen the role and importance of the "honest broker", which played an important role within the convention. "When you want to achieve something there must be something in it for everybody."

In contrast to most other conventions, the CLRTAP included the scientific research and monitoring directly under the Convention and close connections between science and policy were made. Annual reporting of scientific achievements made it possible for the policymakers to continuously be updated on the most recent findings.

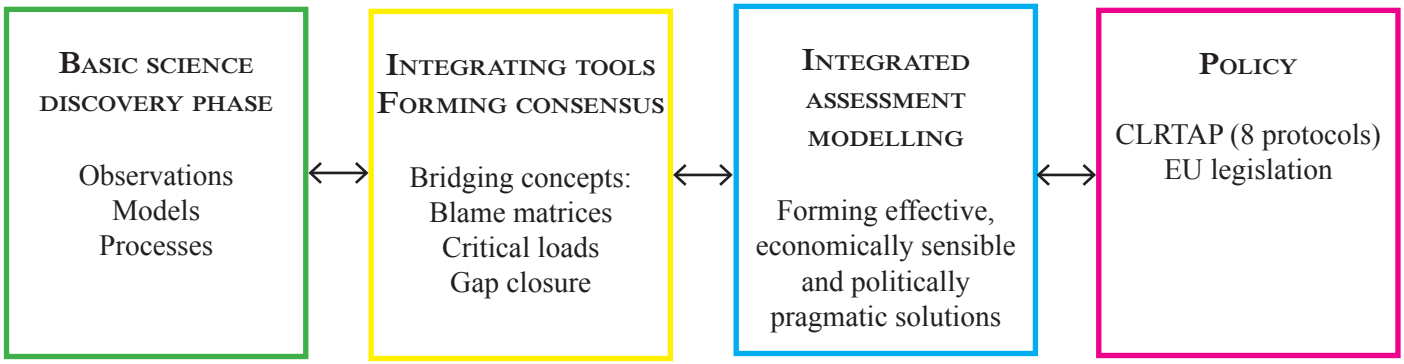
Anna Engleryd continued saying that trust and legitimacy is of crucial importance and has developed over time. Scientists are used to stay within their areas, and so do often policymakers too, while politicians come and go. Many scientists and policymakers have become so fascinated of their issue that they have devoted themselves to it.

Markus Amann pointed to the importance of quality control including peer review and strict quality assurance quality control procedures. He also stressed the value of independent institutions, which was further highlighted by Peringe Grennfelt, who specifically mentioned the value of the Nordic Council of Ministers and its long term support to scientific research and to science exchange with the international bodies.

Several participants at the symposium pointed to the strong involvement of scientists in communication of the problem. It was also recognised that the acid rain problem to a large extent was communicated by scientists direct to policymakers, media and the public. Svante Odén didn't choose the traditional way of presenting the problem through a scientific article in a prestigious journal. Instead he presented it directly to the public through an article in a newspaper. The public including the politicians were in this way involved in the scientific findings from the very beginning. And since the problem was presented by a scientist, there was already from the start a face behind the findings. Bedrich Moldan

The learning from acid rain about the role of science

- Bridging science and policy



The simple scientific support in terms of a general understanding of the acid rain problem developed for the first sulphur protocol has since then developed to an advanced integrated approach supported by advanced models.
Today's support includes several compounds and interacting policies such air quality, reactive nitrogen, acid deposition, climate, food, energy, water etc. It should also take into account the different scales from local to global and interests from various stake-holders: governments, citizens, industry organisations. (From Øystein Hov's presentation)

mentioned that the cooperation with media and the full transparency were absolutely necessary during the 1980s before the breakdown of the communist regimes.

The acid rain problem was favoured by visible and easily communicable effects. At the symposium examples were given both on the acidification of lakes in Norway and on the forest damages in Germany and Czechoslovakia of that time. Experimental research sites have also played an important role, as were exemplified by the projects at Risdalasheia in Norway, Lake Gårdsjön in Sweden and at Soling in Germany. On site, scientists, NGOs, policymakers, politicians and industry representatives were able to see effects and get an understanding of the causes and mechanisms of the acidification.

Several concluded that even though the impact of other environmental problems is more difficult to communicate unequivocally, using visible research results and involving scientists are of crucial importance for the understanding and acceptance of the problem.

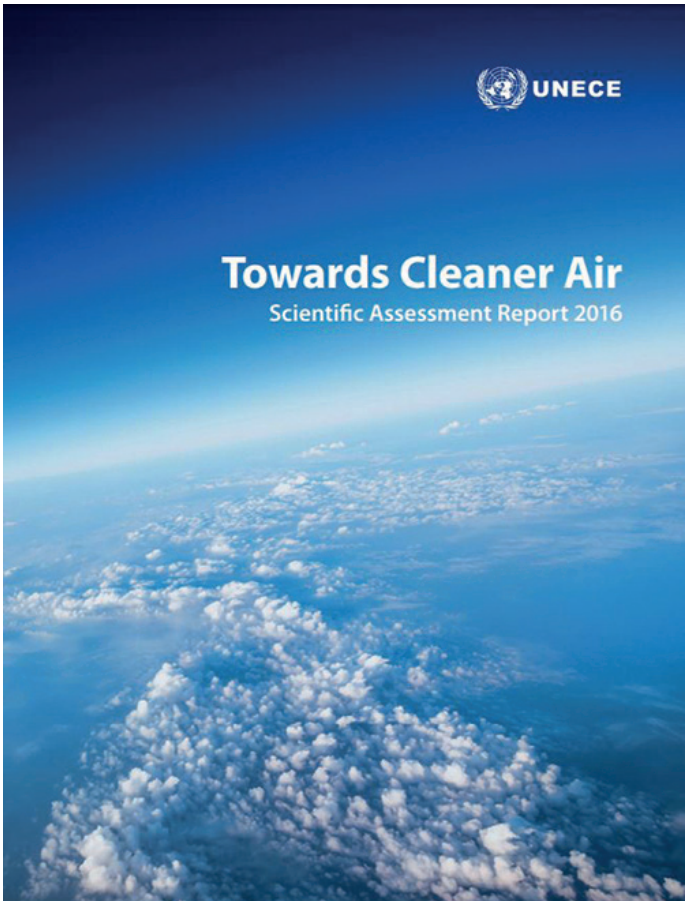
Ways forward and new challenges

An important part of the symposium was to discuss future challenges, both in terms of needs within the air pollution area but also with respect to how experience from the acid rain and international air pollution field can be used to tackle new problems.

Air pollution is today a more complicated issue than it used to be. Several of the participants argued that future policies need to be seen in the perspective of climate change and climate change policies. Laurence Rouil claimed that we need to have a win-win-perspective in the future and work together with other areas such as energy, agriculture, transportation, urban planning etc. to meet the challenges to reduce air pollution. Some specific research issues were mentioned, e.g. a better understanding of health effects from air pollution, nitrogen effects to ecosystems and the interaction with climate in terms of carbon storage in ecosystems.

We need to keep the infrastructure but develop it to meet future challenges. We also need to mobilise new generations of scientists; scientists that are willing to cross borders and focus on thematic problems that are more important than research within their own disciplines.

Annica Ekman emphasised that the research communities within air pollution and climate change need to talk much more to each other. There is also a need to continue to integrate between disciplines. With the increased computer power, for example within climate change research, we can integrate atmospheric chemistry into the climate models and look simultaneously at air pollution



The CLRTAP's Assessment Report Towards Cleaner Air from 2016 forms a key scientific document from which the Convention is now developing its future policy.

and climate change. The modelling approach can be further developed using modelling and monitoring systems that cross boundaries and help us understand the flows and interactions between different compartments – atmosphere, terrestrial ecosystems and aquatic ecosystems.

Øystein Hov added that the problem can be approached through earth system analysis covering aspects related to sea, atmosphere, climate, ecosystems and weather in which air pollution and its consequences is one element. These models can be run in a forecast mode like weather forecasts. Air pollution becomes an integrated part in such a model system and will give information that goes far beyond individual models and monitoring.

Åke Iverfeldt widened to include the challenges of the Sustainable Development Goals (SDGs): We are forced to take the next step in environmental policy and research and through the SDGs we are facing a multitude of goals and objectives. How to share prosperity in the world is one important issue. Perspectives are rapidly changing from a production perspective to a consumer perspective. This is a new context to address. Obvious parts in this are both bio-economy and energy. We are also facing disruptive changes, e.g. in the transportation sector, where the direction today goes towards accessibility. We are moving upwards in the value chain and closer to the consumer needs.

At the same time as Karolina Skog expressed her thanks to those that have "given their hearts" to the acid rain and related problems, she urged that we need to continue and increase our efforts. She highlighted air pollution effects to human health, in particular with respect to children. She stated that we often need some crisis or event to put air pollution on the agenda, such as the Volkswagen cheating on NOx emissions. That example shows that we still have problems with mistakes even if we want to bring science and policy together. Five years ago the message was that diesel cars were environmentally fair, but today we know that was a mistake.

Today we have strong institutions which make it much harder for scientists and individuals to influence and make a difference. We need to look for windows of opportunity in the same way as we have seen within the area of transboundary air pollution.

Øystein Hov mentioned that there is a law for the protection of the atmosphere underway initiated by the International Law Commission (ILC). We need to see if and how this global approach will influence the future of air pollution policy and how we will be able to adopt that way of thinking since interests are presently moving from the global to the national and local scales. Karolina Skog mentioned that UNEA 3 has taken a strategy on board for regionalising actions against air pollution and that might be an area where there will be needs for science.

Markus Amann highlighted that we live in a society where science is challenged and we need to be aware that communication of scientific results have become more difficult. Karolina Skog argued that we must rethink the relation between science and policy and stand up for the idea of building policymaking on science. "Today we need scientists in the public domain." We also need politicians that are ready to listen to science. We need a more critical view on information and to ask for sources from where we get the information. Our belief that the development of policymaking and science is a straight way forward is today challenged.

Public awareness is very important for deciding the way forward. We need to take the role of citizens into account. They have become more interested and want to be involved in decisions. We have a role to involve and communicate with the general public. There are however areas that are difficult to explain, such as the role of open firing of wood. Fish extinction was an awareness raiser. It was rather immediate and people in Norway and Sweden could see the effects. We try to use that also in climate change. We try to use the same language talking about crisis, disaster and emergency, but people don't see the threat right away and don't understand the urgency. The language used and its value is here very important.

Communication experts have a tendency to deplete the value of language as can be seen in politics, science and institutions. It is important not to use the strong words too frequently. And it is always a competition between interests. The public have difficulties to see which issues are of major concern or which are just a product of a clever spin doctor.

Karolina Skog pointed in particular to the importance of openness and transparency and that the experience from acid rain should be transferred into other areas. Trust is also a key in the long term development. She referred to the area of chemicals – an area where we suffer from lack of openness and trust. We have a lot of emotions and rumours in that debate and as a consequence, it has been very ineffective. She continued: "Please stay in the public debate. We desperately need you."

Åke Iverfeldt added that we must use the experience from acid rain when forming dialogues and trust, and that we also need to understand the political agendas to know where to find ways forward.

In the final summing up of the symposium John Munthe pointed in particular to the challenges we are facing in terms of lack of trust, not only for science but also for governments, and that citizens don't lose confidence. He also stressed the need for us to handle "alternative facts" and pointed to the changes in interest and priorities for research, not least from the European Union. Today there is no room for research linked to traditional environmental problems; instead priorities go towards increasing the competitiveness of Europe in the global arena. ■

Programme Acid Rain Symposium

Stockholm, November 6-7, 2017

November 6th

How did it happen?
Chair: Peringe Grennfelt and Øystein Hov

09:30 Welcome: Swedish Environmental Protection Agency, Björn Risinger and UN ECE, Anna Engleryd
09:45 The early discoveries. The legacy of Svante Odén. Henning Rodhe
10:05 How science formed a breakthrough for international acid rain policies. Lars Walløe
10:25 Science and policy interactions in Europe over 50 years. Peringe Grennfelt
11:05 The North American perspective – science and policy. Ellis Cowling
11:35 The science, politics and policy of air pollution diplomacy. Karin Bäckstrand
11:55 Discussion. Introduction. Göran Persson
12.30 Lunch

Science for policy. What have we learned?
Chair: Harald Dovland

13:20 The scientific landscape. Threats and opportunities. Øystein Hov
13:40 The policy landscape. Old bodies and new initiatives. Anna Engleryd
14:00 Blame Matrix and Gap Closure: Useful concepts. Anton Eliassen
14:20 Science-based prescriptive policies. Integrated assessment modelling. Markus Amann
15:00 The importance of science for policy development. Air pollution in an international and historical context. Introduction: Swedish Minister of Environment Karolina Skog. Panel discussion between some representatives from key organisations acting in the field: Swedish Ministry of Environment, Karolina Skog, IIASA, Markus Amann, CLRTAP, Anna Engleryd, European Commission, Carsten Larsen, Norwegian Ministry of Environment, Jan Thompson and AirClim, Christer Ågren
16:25 Acid rain – Controversies and breakthroughs. During the 80s there were intense discussions on the role of science as a basis for control measures. How important were these discussions for the international political acceptance of the problem and what can we learn?
Panel discussion: introduction by Harald Dovland, David Fowler, Bedrich Moldan, Jan Nilsson, Arne Tollan

17:15 End, followed by dinner at the Royal Swedish Academy of engineering sciences (IVA)

November 7th

Experience and future challenges

Chair: Alex Estlander

09:00 Opening. Alec Estlander
09:05 Dead fish in lakes and streams. Brit Lisa Skjelkvåle
09:25 Forest die back – Scientific findings, public debate and policy response. Karl Josef Meiwes
09:45 The recovery in Eastern Europe. Jakub Hruska
09:55 Coordinated monitoring brings countries together. Kjetil Tørseth
10:15 Critical Loads - Link between Science and Policy. Max Posch
10:55 From the urban to the global scale. Laurence Rouil
11:15 Ecosystems - evidence of recovery but still under threat. Isaura Rabago
11:35 Acid rain in an East Asian perspective. Xiaobin Xu
11:55 Discussion
12.25 Lunch

Lessons learned and the wider perspective

Chair: Anna Engleryd

13.15 Health effects from acid rain and air pollution. Elisabeth Lindgren
13.35 Air pollution, climate change and food. David Fowler
13.55 Sulphate, soot and climate. Annica Ekman
14.15 Ecosystem effects of N and S deposition in the future: Filip Moldan and Julian Aherne
15.10 Lessons learned and ways forward. Introduction: Øystein Hov
15.25 Panel discussion: Chair Stefan Nyström, Julian Aherne, Xiaobin Xu, Laurence Rouil, Annica Ekman, Åke Iverfeldt
16.15 Summing up. Conclusions. John Munthe
16:30 End of the symposium

List of Participants

Wenche Aas, Norwegian Institute for Air Research (NILU), Norway
Julian Aherne, Trent University, Canada
Markus Amann, IIASA, Austria
Ulla Bertills, Sweden
Lars Björkbom, Former Swedish Ministry of Environment, Sweden
Göran Bäckstrand, Swedish Red Cross, Sweden
Karin Bäckstrand, Department of Political Science, Stockholm University, Sweden
Ellis B. Cowling, North Carolina State University, United States
Betsy Cowling, United States
Harald Dovland, Carbon Limits, Norway
Annica Ekman, Stockholm University, Sweden
Anton Eliassen, Norwegian Meteorological Institute, Norway
Anna Engleryd, Swedish Environmental Protection Agency, Sweden
Alec Estlander, TFiF, Finland
Hilde Fagerli, Norwegian Meteorological Institute, Norway
Martin Ferm, IVL Swedish Environmental Research Institute, Sweden
Martin Forsius, Finnish Environment Institute, Finland
David Fowler, Centre for Ecology and Hydrology, UK
Jens Fölster, SLU, Sweden Swedish University of Agricultural Sciences
Ann-Sofie G Vetander, IVL Swedish Environmental Research Institute, Sweden
Anna Gran, Nordic Council of Ministers' Climate and Air Pollution Group (KOL), Denmark
Lennart Granat, Stockholm University/Department of Meteorology, Sweden
Peringe Grennfelt, IVL Swedish Environmental Research Institute, Sweden
Hiroshi Hara, Tokyo University of Agriculture and Technology, Japan
Leen Hordijk, Wageningen University, Netherlands
Øystein Hov, The Norwegian Academy of Science and Letters/Norwegian Meteorological Institute
Gunnar Hovsenius, Svenska Luftvårdsföreningen, Sweden
Jakub Hruska, Charles University and Czech Geological Survey, Czech Republic
Åke Iverfeldt, Mistra, Sweden
Johanna Janson, Ministry of the Environment and Energy, Sweden
Sara Jutterström, IVL Swedish Environmental Research Institute, Sweden
Pekka Kauppi, University of Helsinki, Finland
Umesh Kulshrestha, Jawaharlal Nehru University, India
Carsten M. Larsen, European Commission
Lars Erik Liljelund, SEI, Sweden
Lars Lindau, Sweden
Elisabet Lindgren, Stockholm University, Sweden
Stefan Löfgren, Swedish University of Agricultural Sciences, SLU, Sweden
Rob Maas, RIVM, Netherlands
Karl Josef Meiwes, Northwest German Forest Research Station, Germany
Filip Moldan, IVL Swedish Environmental Research Institute, Sweden
Bedrich Moldan, Charles University Prague, Czech Republic
John Munthe, IVL Swedish Environmental Research Institute, Sweden
Jan Nilsson, Sweden
Thomas Nilsson, Mistra, Sweden

Lars Nordberg, Ex CLRTAP Secretariat, Sweden
Stefan Nyström, Swedish Environmental Protection Agency, Sweden
Göran A Persson, Sweden
Max Posch, CCE/RIVM, Netherlands
Isaura Rabago, CIEMAT, Spain
Björn Risinger, Swedish Environmental Protection Agency, Sweden
Henning Rodhe, MISU, Sweden
Bjørn Olav Rosseland, Norwegian University of Life Sciences, Norway
Laurence Rouil, INERIS, France
Steinar Sandøy, Norwegian Environment Agency, Norway
Richard Skeffington, University of Reading, UK
Brit Lisa Skjelkvåle, University of Oslo/NIVA, Norway
Karolina Skog, Swedish Minister of Environment
Gunnar Skotte, Norwegian Environment Agency/ICP Waters, Norway
Jan T. Thompson, Ministry of Climate and Environment, Norway
Eva Thörnelöf, Swedish Environmental Protection Agency, Sweden
Arne Tollan, NVE, Norway
Kjetil Tørseth, Norwegian Institute for Air Research (NILU), Norway
Maria Ullerstam, Swedish Environmental Protection Agency, Sweden
Salar Valinia, Swedish Environmental Protection Agency, Sweden
Lars Walløe, University of Oslo, Norway
Anders Wikman, IVL Swedish Environmental Research Institute, Sweden
Anders Wilander, Swedish University of Agricultural Sciences, Sweden
Malene Vågen Dimmen, Miljødirektoratet, Norway
Xiaobin Xu, Chinese Academy of Meteorological Sciences, China
Christer Ågren, AirClim, Sweden
Eli Marie Åsen, Ministry of Climate and Environment, Norway

Short Presentation
of speakers, chairs and panelists

Julian Aherne, Associate Professor, School of environmental, Trent University, Canada. Julian is an ecosystem modeler with a focus on understanding the impacts of air pollutants on the environment. He is particularly focused on modelling of biogeochemistry in forest ecosystems.

Markus Amann is Program Director for 'Mitigation of Air Pollution and Greenhouse Gases' at the International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria. He is coordinating the policy analyses on cost-effective emission control strategies for the clean air and climate policy proposals of the European Commission and the Convention on Long-range Transboundary Air Pollution. He has been leading the development and application of the RAINS and GAINS models in connection with the development CLRTAP protocols and EU strategies.

Karin Bäckstrand is a Professor in Environmental Social Science at the Department of Political Science at Stockholm University with a PhD in political science from Lund University. Her research revolves around global environmental politics, the role of science in international air pollution diplomacy, and the politics and policy of climate change. She has held positions as a Wallenberg Fellow for Environment and Sustainability at the Massachusetts Institute of Technology and as a visiting professor at Department of International Relations at the University of Oxford. Her latest books are The Research Handbook on Climate Governance (with Eva Lövbrand, Edward Elgar, 2015) and Rethinking the Green State: Environmental Governance towards Climate and Sustainability Transition (with Annica Kronsell, Routledge, 2015).

Ellis Cowling is a forest biologist at North Carolina State University who became a world leader in environmental research. He completed PhD degrees in Plant Pathology and Biochemistry at the University of Wisconsin in 1959 and in Physiological Botany at the University of Uppsala in Sweden in 1970. He was elected to membership in the US National Academy of Sciences in 1973. During a sabbatical year in Sweden in 1970-71 he shifted his personal research to "acid rain" and other impacts of airborne chemicals on terrestrial and aquatic ecosystems. In 1975-83 he provided leadership for development of the National Atmospheric Deposition Program (NADP) and in 1978-79 he was one of four scientists who provided an initial outline for the National Acid Precipitation Assessment Program (NAPAP).

Harald Dovland worked for more than twenty years at the Norwegian Institute for Air Research (NILU), mainly on issues related to long-range transport of air pollutants and was its managing director from 1988 to 1995. He then moved to the Norwegian Ministry for the Environment where he worked mainly on climate change issues. He was Head of the Norwegian delegation to the negotiations under the UNFCCC until 2007. He has been actively working under the CLRTAP. From 2000 to 2005, he served as chairman of the Executive Body of the CLRTAP. After retirement in 2011 he has been working with issues related to climate change.

Annica Ekman is a professor in meteorology at Stockholm University and the Bolin Centre for Climate Re¬search. Her research focuses on aerosol particles in the atmosphere and how they affect radiation, clouds, precipitation and climate. To study these processes, she develops numerical models on scales ranging from local to global.

Anton Eliassen has been involved in transboundary air pollution issues since the early 1970s, in particular with respect to the development and application of atmospheric dispersion models for various air pollutants. These models have been central for the CLRTAPs policy work, in particular for so called source – receptor matrices. He retired as director of the Norwegian Meteorological Institute in 2016.

Anna Engleryd works at the Swedish Environmental Protection Agency and is since many years involved in international negotiations on air pollution. Since December 2014 she is Chair of the Executive Body to the Convention on Long Range Transboundary Air Pollution.

Alec Estlander started his air career at Finnish Meteorological Institute, where he built up the EMEP network in Finland. He was involved in the preparations for the CLRTAP in the Nordic context and in Geneva. He was vice chairman of EMEP for some time. He joined the Ministry of the Environment in 1983 in charge of air pollution matters. Six years later he started working as a consultant and in 1999 he joined the Finnish Environment Institute heading the department for environmental loading. All his active years he was heavily involved in Nordic cooperation. He was awarded the honorary title Environmental Councillor after his retirement.

David Fowler, Trained in Environmental Physics and Nottingham University, and completed a PhD at AERE Harwell on the Dry Deposition of sulphur dioxide to terrestrial surfaces. Joining the Centre for Ecology and Hydrology (CEH) in Edinburgh in 1975 and working on the land-atmosphere exchange of pollutants gases and aerosols and their effects on ecosystems over the subsequent 42 years. In addition to publications in his specialist field he focussed on the policy applications of the research with UK and International Agencies. Elected to the Royal Society of Edinburgh in 1999 and the Royal Society of London in 2002.

Peringe Grennfelt, IVL Swedish Environmental Research Institute since 1969. His main scientific areas have been air pollution and interactions between air pollution and policy. He has been working with international air pollution issues his entire career and been involved in UNECE work as a national expert since 1985 and served as chair for the Working Group on Effects between 2011 and 2016.

Øystein Hov is currently Secretary General at The Norwegian Academy of Science and Letters. He is also a part time adviser to the Director of the Norwegian Meteorological Institute, and is the president of the Commission for Atmospheric Sciences in WMO. He is a meteorologist and atmospheric chemist.

Jakub Hruška (1964) graduated in chemistry from Charles University, Prague, in 1988. Since the beginning of his career at the Czech Geological Survey, he has taken interest in acid rain effects on soil, water and forests in the so called ”Black Triangle“ region of Central Europe. He has been working mostly on acidifica¬tion recovery, its biogeochemical modelling, and DOC/acidity relationship. He spent his post-doc at SLU in Umea (1997-1998) and has been a Professor of Environmental Sciences at Charles University since 2015. He also organized ACID RAIN conference 2005 in Prague.

Åke Iverfeldt, CEO of Mistra since 2013. Previously Vice Executive Director of IVL and before that an atmospheric chemist working internationally with long-range transport of mercury.

Karl Josef Meiwes is a soil scientist. He has worked at University of Göttingen (together with Prof. B. Ulrich), at the Forest Research Station of Lower Saxony, Göttingen, and then as Senior Soil Scientist at the North West German Forest Research Station, Göttingen. Scientific background: Soil chemistry, forest nutrition, biogeochemistry of forest ecosystems, intensive monitoring of forest ecosystems (level II), forest management and nutrient cycling, fertilization.

Bedrich Moldan is Professor in environmental science at the Charles University in Prague where he teaches, He is also a founder the Environment Center and was its Director from 1991 to 2014. Between 2004 and 2010 he served as the Senator of the Parliament of the Czech Republic. His experience includes research on indicators of sustainable development and various aspects of science-policy interface. In 2010 he received the SCOPE-Zhongyu Environmental Award for lifetime achievement. He was for many years deeply involved in the acid rain problem and was the key organiser of the Acid Rain Conference in Prague 2005.

Filip Moldan, Ph D, is scientist at IVL Swedish Environmental Research Institute who works with effects of air pollution, land use and climate change on soils, waters and forests. He works with large scale ecosystem experiments, with dynamic models and with monitoring. Filip is also involved in Swedish reporting to ICP Modelling and Mapping and to ICP Integrated Monitoring and is chair of Joint Expert Group on Dynamic Modeling under the CLRTAP.

John Munthe, Vice President, Research at IVL, has more than 25 years´ experience of research and consulting on environmental pollution including mercury, organic contaminants and air pollutants. He is currently program manager for the SCAC program, funded by the Swedish Environmental Protection Agency and focused on providing scientific support for policy development in air pollution and climate.

Jan Nilsson, Retired since 14 years. He was research director at the Swedish EPA for 15 years and programmes director at Mistra (the Foundation for Strategic Environmental Research) for 10 years. Initiated the concept "critical load".

Stefan Nyström, economist, Director of the Climate department at the Swedish Environmental Protection Agency since 2016. He has before that been Secretary General of the Swedish Anglers Association (2001- 2014) and head of the All Party Committee on Environmental Objectives (2014-2016)

Göran A Persson, managing director at Mistra Foundation 1994-1999 and deputy minister of Environment and Natural Resources 1991-93. He worked with the Swedish Environmental Protection Agency between 1967 and 1991, for many years in leading positions and as deputy director general between 1988 and 1991. He was deeply involved in the early development of international research and collaboration on acid rain and initiated several international initiatives i.a. the OECD project on Long Range Transport of Transboundary Pollutants. He is chairing the Energy and Environment Committee at the Royal Academy of Engineering Sciences.

Maximilian Posch holds a Ph.D. in physics and a master's degree in mathematics from the Technical University of Vienna. He worked at IIASA in Laxenburg (Austria) between 1981 and 89 on the integrated assessment of acidification in Europe (the RAINS model). 1990–1994 he worked at the Finnish Water and Environment Research Institute on the environmental impacts of acid deposition and agricultural practices. Since 1995 he is senior researcher at the Coordination Centre for Effects (CCE) at the Dutch National Institute for Public Health and the Environment (RIVM).

Isaura Rabago is a senior researcher at CIEMAT (Research Centre on Energy, Environment and Technology) working at the Unit of Modelling and Ecotoxicology of Air Pollution. Currently she chairs the Working Group on Effects of the UNECE-LRTAP Convention since 2016.

Björn Risinger is since 2015 Director General for the Swedish Environmental Protection Agency. He was before that Director General for the Swedish Agency for Marine and Water Management and the National Board of Fisheries. He has also been holding leading positions in the county administrations.

Henning Rodhe, Royal Swedish Academy of Sciences; Henning Rodhe is a professor emeritus (Chemical Meteorology) at the Department of Meteorology and the Bolin Center for Climate Research at Stockholm University, Sweden. His main research focus has been atmospheric aerosol particles and their impact on ecosystems and climate.

Laurence Rouil is the head of the "Environmental modelling and decision making" department at INERIS. She received her Ph.D in 1995 in the field of applied mathematics. Her main area of experience is air quality modelling. For more than 15 years she has developed skills and competence being the leader of research activities closely linked to operational applications within air pollution modelling and forecasts. Since September 2014, she chairs the EMEP Steering Body of the UNECE Convention on Long Range Transboundary Air pollution.

Brit Lisa Skjelkvåle has a PhD in geology (geochemistry). Her research is focused on the effects of LRTAP on freshwater systems. She was responsible for the monitoring of freshwater in the Norwegian national monitoring program and also led the program center of ICP Waters from 1996-2013. She has worked 25 years as a researcher at the Norwegian Institute for Water research, and the last four years as Head of Department at the Dept of Geoscience at the University of Oslo.

Karolina Skog is Minister of Environment and Energy in the Swedish Government since 2016. Before that she was municipal commissioner in the city of Malmö with responsibility for urban development.

Arne Tollan, MSc in geosciences 1961 from Oslo University. Ass. director of the SNSF research programme on acid rain 1976-80. Ass. director of Norwegian Water Research Institute, NIVA. Head of Air pollution div., UNECE, Geneva, 1983-85. Director of Hydrology Dept. NVE 1986-1998. Secondment at European Environment Agency, EEA, Brussels 1992-93. Participation in numerous projects within water resources development in Asia and Africa. Retired from NVE 2008.

Jan T. Thompson is an economist by training, has a professional background mainly from the Ministry for the Environment, where he served as Director General for the Department of International and Polar Affairs from 1985 until 1996. His area of responsibility included i.a. cooperation on transboundary air pollution. He was for 11 years Chairman of the Executive Body for the CLRTAP and took actively part in the negotiations on the Convention on Climate Change. He was among the founders of Nordic Environment Finance Corporation, NEFCO, where he is a member of the Board of Directors. He is at present a Senior Advisor in the Norwegian Ministry of Climate and Environment, focusing on environmental financing.

Kjetil Tørseth is director of Atmospheric and Climate research at NILU. His PhD addressed deposition fluxes of sulphur and nitrogen components, and he has been central in the mapping of critical load exceedances in Norway. He has been engaged in the Norwegian monitoring of long-range transported air pollutants since 1992, and has since 2000 served as head of the EMEP Chemical Coordinating Centre. He is also engaged in WMO Global Atmosphere Watch, and has participated in many international research projects.

Lars Walløe, Professor of Physiology (Faculty of Medicine, University of Oslo) 1988-2008, now Professor emeritus. Previously Professor of Informatics (Faculty of Science, University of Oslo) 1978-1988. Director of the Norwegian research on Acid Rain (SNSF) 1976-80. Member of the Management group of the UK-Scan¬dinavian Surface Waters Acidification Programme (SWAP) 1984-90. President and Vice-President of the Norwegian Academy of Science and Letters alternate years 1997-2004. President of Academia Europaea 2008-2014. Chairman of many different Norwegian and European research bodies. Currently Chair of the Environment steering panel of EASAC (European Academies Science Advisory Council).

Xiaobin Xu, PhD Laboratory for Atmospheric Chemistry, Centre for Atmosphere Watch and Services, Chinese Academy of Meteorological Sciences, China Meteorological Administration Beijing China.

Christer Ågren, Representing the Air Pollution and Climate Secretariat (AirClim), Christer Ågren has more than 35 years of experience of working with air pollution, including being an NGO-observer to the Air Convention (CLRTAP), the International Maritime Organisation, and to the air quality policy processes of the European Union. Additional work experience includes being Head of Section at the Swedish Ministry of Environment and designated expert to the Environment Directorate of the European Commission, with the main tasks to develop an EU Strategy to Combat Acidification. More information: www.airclim.org.

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