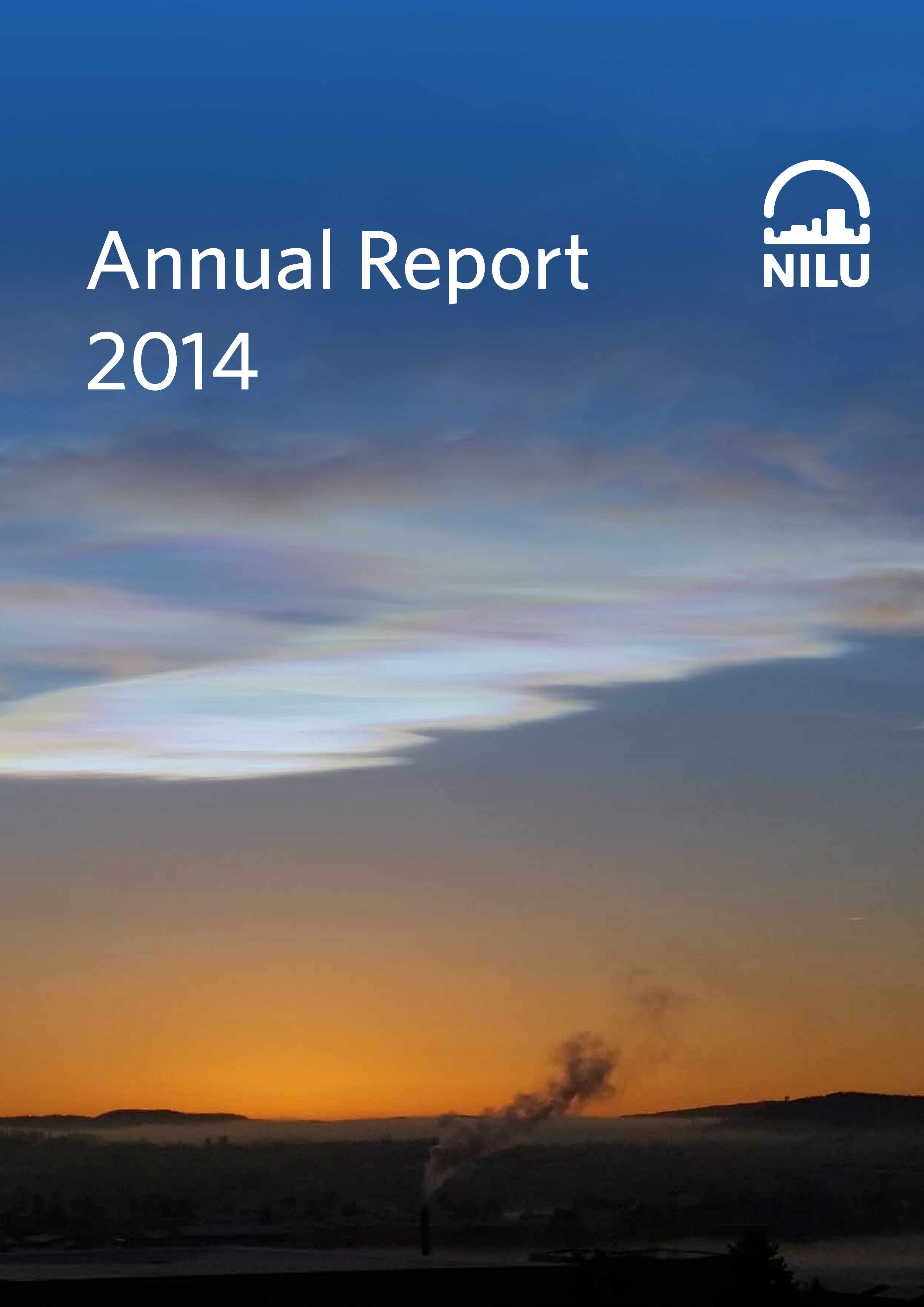
Annual Report 2014

NILU



Contents

Christine F. Solbakken, editor.
Finn Bjørklid, Ingunn Trones, Sonja Grossberndt,
Mike Kobernus and William A. Lahoz, contributions and adaptions.

Front page: Mother-of-pearl clouds over Kjeller.
Photo: Kjetil Tørseth.

45 years of air, atmosphere, environmental pollutants and climate

NILU celebrated its 45 anniversary in 2014, and our regional office in Tromsø turned 20. We have grown from a few pioneers, to a solid institute with world-class expertise and research. Still among us are skilled and loyal colleagues who have been with us from the very beginning in 1969.

2014 was an economically challenging year, with the closure of the department in Abu Dhabi, and the necessary adaptation to this change at the institute in Norway. However, it is gratifying that at the end of the year we got a new five-year framework contract with the environmental authorities in Abu Dhabi, which will ensure further cooperation on climate and the environment.

High North and NILU at the Fram Centre

NILU at the Fram Centre in Tromsø is a key player and partner in the field of environmental chemistry in The High North. The Arctic is located downstream of the major sources of pollution, and persistent organic pollutants are transported here through the atmosphere. Thus, the Arctic is a key area in which to study both long-range transport and climate effects.

Climate

NILU's atmospheric and climate research distinguishes itself with a Nordic Centre of Excellence, major climate projects and expanded focus on climate and environmental pollutants. We are also strengthening our expertise and project portfolio at a regional and local level, related to climate change and knowledge-based mitigation counselling.

A new initiative is climate research related to methane concentrations in the sea and the air, including assessing the role of long-range transport and trading activities, and their historical variation. Here, both atmospheric and oceanic research disciplines meet, something that opens up completely new issues and a more holistic approach to climate research.

Environmental monitoring

The observatories are a cornerstone of NILU's atmospheric research. We moved the Troll observatory in Antarctica to a better location early in 2014 , and the observatory has since changed its name to Trollhaugen. The move has had positive consequences, in that the data now are of high quality, and local pollution is no longer a problem. The data will provide unique contributions to climate research. In addition, we strengthened the Zeppelin observatory at Svalbard in the Arctic with new instrumentation in the past year.

The CIENS collaboration

CIENS is a collaborative centre for NILU, and several other environmental research institutes and the University of Oslo. Our focus is on developing URBAN, a strategic partnership to strengthen relevant environmental and climate research in connection with sustainable urban development.

We have taken a number of initiatives to achieve long-term financing. We are in dialogue with business and industry, and hope that this initiative will develop favourably. We are also keen to ensure relevance in research through extensive cooperation with user partners, such as counties, municipalities and businesses.

Innovation

NILU focuses on innovation in the broadest sense. Our innovation projects are useful to society by contributing to better socio-economic solutions, and in some cases to provide new jobs and added commercialization of products and services.

A brief look at 2014

Under the vision "Research for a clean atmosphere," NILU focuses on four core areas: atmospheric composition, climate change, air quality, and environmental pollutants. Among these areas, air quality and environmental pollutants get the most media coverage, but our research has several facets.

The articles in this annual report provide a cross-section of NILU's business. Here you can read about all we do from the development of air quality models in China, to nacreous clouds, about how blood tests show that conventions to reduce emissions of pollutants actually work, and how to use nanomaterials safely.

Have a good read!

Kari Nygaard

Managing Director

ECLIPSE

Could emission abatement of short-lived climate pollutants help mitigate climate change?

Christine F. Solbakken
Head of Communications

The EU 7th Framework Programme Collaborative Project ECLIPSE developed and assessed effective emission abatement strategies for short-lived climate pollutants (SLCPs) in order to provide sound scientific advice on measures that mitigate climate change and improve air quality at the same time.

– The current climate policy does not take into consideration a range of short-lived gases and aerosols, senior scientist Andreas Stohl explains, – and our goal was to determine their contribution to climate change and their influence on air quality by using state-of-the-art chemistry transport and climate models. While methane is included in the Kyoto Protocol, we also considered it in ECLIPSE as it is much shorter lived than carbon dioxide and also impacts air quality via formation of ozone.

Project goals

During the project, scientists from 11 institutes in Europe and China collaborated to improve understanding of the climate impact of those SLCPs.

They quantified radiative forcing and climate response due to emissions of short-lived species in various regions of the globe, and also assessed the impact on human health via changes in air quality.

Senior scientist Sabine Eckhardt explains that they also wanted to clarify possible win-win and trade-off situations between climate policy and air quality policy, while identifying a set of concrete cost-effective abatement measures for short-lived species with large co-benefits.


Foto: Shutterstock

The scientists also evaluated model simulations of short-lived species and their long-range transport using ground-based and satellite observations, and performed case studies on key source and receptor regions (with focus on Europe, China and the Arctic).

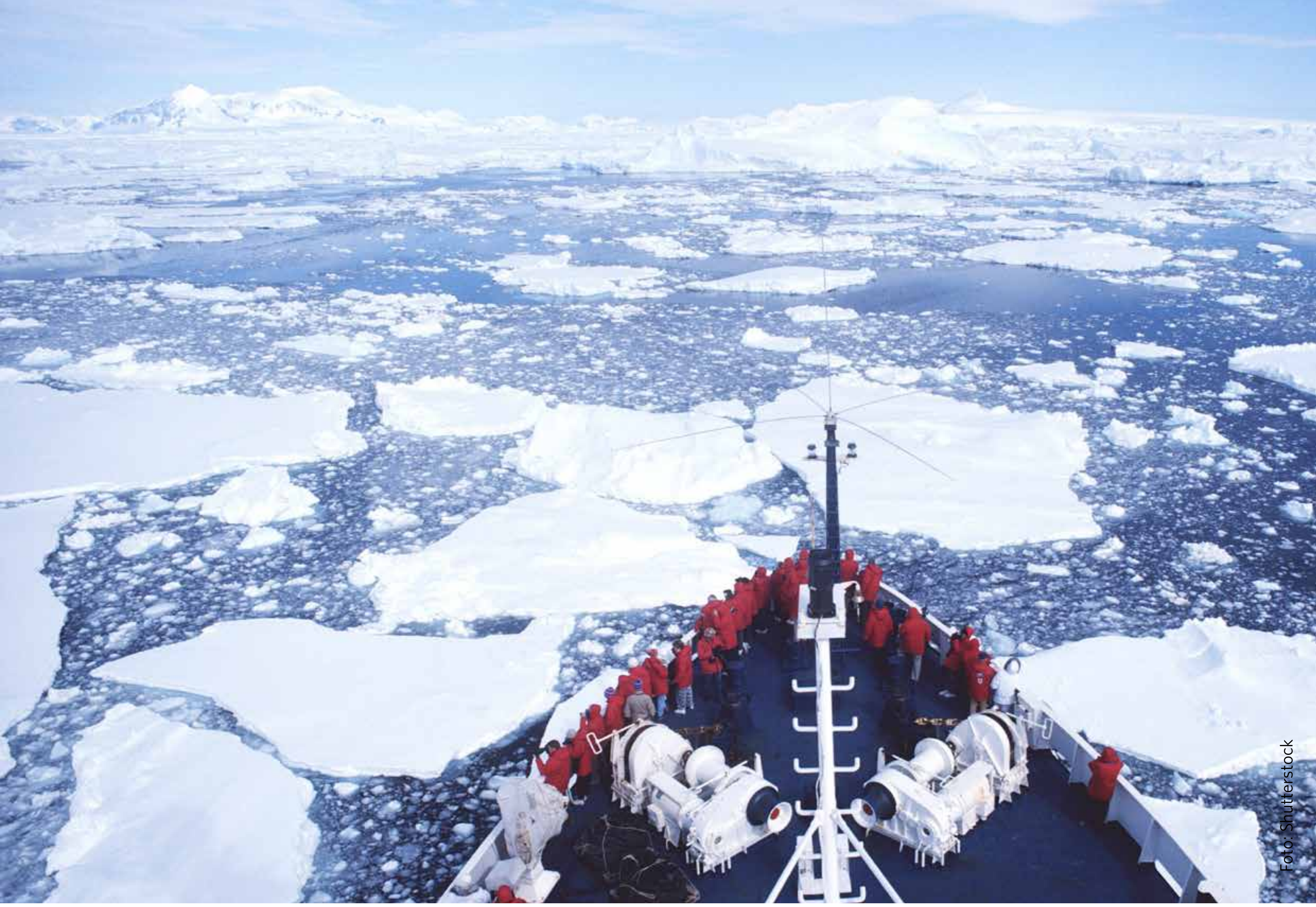
Realistic mitigation scenario

The ECLIPSE scientists used a unique systematic concept for designing a realistic and effective SLCP mitigation scenario, and quantifying the climate and air quality impacts related to the scenario. First they calculated the radiative forcing values for a large array of SLCPs as a function of region, season and the individual substances. Based on these radiative forcing calculations, suitable metrics were chosen to estimate the climate impact of particular SLCP emissions relative to an equal amount of CO_2 emission.

Next, they used these metrics to generate a mitigation scenario for the SLCPs that could be contrasted with the current legislation scenario. For this, the region-, season- and species-specific matrix of climate impact (as defined by the chosen metric) was used as an input to an integrated assessment model. Those emission mitigation measures with a beneficial air quality impact were then evaluated according to their expected climate benefit.

Comparing paths

– It is important to understand that emission measures typically affect several SLCP species, and often some of them are warming the climate while others are cooling, says Stohl. – For every mitigation measure, the net effect needs to be determined by weighing the emission reduction of every SLCP with the chosen climate metric and summing over all emitted SLCP species. Finally, we collect-



ed all measures with beneficial air quality and climate impacts in a basket defining the SLCP mitigation scenario.

The metrics, however, cannot fully quantify the climate response (e.g., changes in precipitation, or regional changes in temperature). Therefore, a second research path determined the climate response by running transient climate simulations in an ensemble of four Earth system models.

A comparison between the climate impacts expected from the metrics and those actually calculated with the transient simulations closed the loop between the first and the second research path, and allowed the scientists to evaluate the consistency of both approaches.

Challenges

There are large uncertainties in estimates of the climate effect of short-lived climate pollutants, and thus also in the effects of emission reductions related to them. Several studies have shown that the climate impact of short-lived components can depend strongly on the location of the origin of the components. Inhomogeneity in the climate response to radiative forcing is also important for the short-lived climate pollutants. The geographical pattern of radiative forcing due to the short-lived climate pollutants (except methane) is generally concentrated close to the source of emission. Hence, they are quite distinct from the global-scale forcing due to the long-lived greenhouse gases.

Results of ECLIPSE

ECLIPSE has identified a set of mitigation measures, which as a whole has beneficial climate and air quality impacts. Especially methane mitigation measures offer large co-benefits as they have beneficial climate and air quality impacts (via reductions of ozone concentrations), but reduction of BC and related emissions would also help improve air quality.

– However, the co-benefits are not as large, as the climate impacts of reducing black carbon (BC) are quite small in our suite of models, explains Stohl. – This is largely because the semi-direct effect of BC offsets a considerable fraction of the direct aerosol radiative forcing. Realizing all ECLIPSE mitigation measures would lead to a reduced climate warming of about 0.22 K for the decade 2041-2050, and some 78-90% of that reduced warming is due to methane emission reductions.

– As CO_2 is the main driver for climate change, reduction of SLCP emissions cannot substitute CO_2 emission reductions for mitigating climate change, says Sabine Eckhardt. – However, the SLCP measures are of a no-regret nature because of substantial improvements in air quality. Especially in developing countries, this will lead to considerable improvements in the quality of life. For instance, we estimate that in India the ECLIPSE mitigation measures would extend the life expectancy by about one year.

Web site: http://eclipse.nilu.no

Research for a clean atmosphere

Preparation of water samples for siloxane analysis.
Photo: Nicholas Warner, NILU.

NILU – Norwegian Institute for Air Research was established as a foundation in 1969. Our research aims to increase the understanding of processes and effects related to our core business areas: atmospheric composition, climate change, air quality and hazardous substances.

The institute holds a strong position both nationally and internationally, and we are among the leading professionals in the world within our core research fields. We provide services closely linked to our research, and have extensive experience in coordinating national and international research projects. Our key clients include the EU, the Research Council of Norway, industry, and both central and local authorities.

NILU's departments

NNILU's research has a wide range, and explores most aspects of what affects the atmosphere, environment and climate. The institute's composition, represented by our various departments, reflects this:

The Atmosphere and Climate Department (ATMOS) does research on air pollution at regional (European) and global levels, greenhouse gases and climate drivers, volcanic ash transport and dispersion, ozone and UV. The department also conducts extensive international cooperation and serves as a data centre for a variety of measurement and research programmes.

The Urban Environment and Industry Department (INBY) conducts research on issues regarding local and regional air pollution. Their research ranges from development of air quality management systems in large cities, to developing systems that include greenhouse gas emission and local air pollution. In addition, the department plays a leading role in Norwegian environmental monitoring and research on industrial emissions.

The Department of Environmental Impacts and Economics (IMPEC) works primarily with exposure and effect studies, cost-benefit analysis and socio-economic studies on the effects of pollution on the environment. The department is particularly involved in projects focusing on European coastal zones.

The Environmental Chemistry department (MILK) does research on new and established pollutants, and has expertise in all types of environmental samples from air, water and sediment to biological material. The department has a particular focus on contaminants in the Arctic, and has two laboratories at its disposal, one at the main office at Kjeller, and one at the Fram Centre in Tromsø.

The Monitoring and Instrumentation Technology Department (MIT) is responsible for operational management of NILU's field measurements, sampling equipment and instrumentation. The department is also responsible for data collection and quality assurance, in addition to the operation of NILU's observatories in Ny-Ålesund at Svalbard, Queen Maud Land in Antarctica, Birkenes in Southern Norway and Andøya in Northern Norway.

The Software and Hardware Development Department (SHADE) is responsible for development and maintenance of NILU's software and hardware products, from the cutting-edge AirQUIS air quality model, to project web sites and adaptation of modules and databases.

In addition, NILU includes an **innovation department**, working to ensure the highest possible utility value of the institute's research. The department's primary goal is to make the results from NILU's research available to the public and policy makers, and whenever possible create commercial development from this.

Photo: Shutterstock

Hubei-AQ.info – Air quality forecasting in China

Wuhan is the capital of the Hubei province, and the most populous city in Central China with around 10 million people. As many other Chinese cities, Wuhan and the other 8 cities in the so-called "Wuhan city cluster" suffer from severe air pollution.

Christine F. Solbakken
Head of Communications

As part of the EU – China Environmental Governance Programme (EGP), the Europe Aid Project *Hubei air quality information and early warning system – complementing Hubei "1+8" city cluster haze monitoring (Hubei-AQ.info)* was started in December 2012, with NILU as coordinator. The goal of the project was to demonstrate and provide air quality (AQ) information, especially air quality forecasting, to the public.

Air quality forecasting

– The Chinese authorities actively try to move forward, says project coordinator and senior scientist Li Liu, from NILU, – and health impact from air pollution is a large concern to the public and the government. Thus, it was essential for the project to develop an AQ information and forecasting system able to provide near-real time information and forecasting on the air pollution situation for the public.

– As the project could not cover all the nine cities from the beginning, NILU and their local partner, the Hubei Environmental Monitoring Centre (HBEMC) under the Hubei provincial Environmental Protection Bureau (EPB), decided to start with Wuhan, explains Liu.

The demonstrated forecasting system provides a detailed air quality forecast for a large part of Wuhan city, including major roads. The forecasting results are available online to the public. Since the system is scalable, it is possible to duplicate it for other cities and provinces.

AirQUIS

To establish an air quality information and forecasting system, the project began with applying the integrated air quality information system (AirQUIS), developed by NILU, for Wuhan.
The AQ forecasting is based on a multi-scale modelling system, so it can be scaled-up and applied in other cities depending on the need. However, it is essential that the input data is improved, especially emissions data for traffic, industry and other area sources. The user-friendly interface of AirQUIS makes it easy to work with partners from different backgrounds, when collecting such information.

The system contains several modules, such as AQ, emissions and meteorological databases, statistical modules for air quality analysis, and a module for emission dispersion.

Traffic emission inventory

Quantifying and understanding the air pollution contribution from vehicles is a requirement when it comes to implementing effective control measures in a city. As traffic emission information was initially missing in Wuhan and the other cities, the project developed a detailed traffic emission inventory for Wuhan, including all major roads.

– The tool and methodology developed through the project will ensure that the local partner is able to continue to include more roads and cities in the future, says NILU engineer Dam Thanh Vo.

Training and exercises

– Working with the Chinese team has been a good experience, says Liu. – They have been very open about sharing information and collaborating with us, and in turn, we have provided the necessary courses, exercises and hands-on demonstrations needed to understand and apply the modelling system, understand emissions data, use AirQUIS, and expand these systems in the future.

All the training materials were delivered to HBEMC, and are available for all nine cities in the Hubei province.

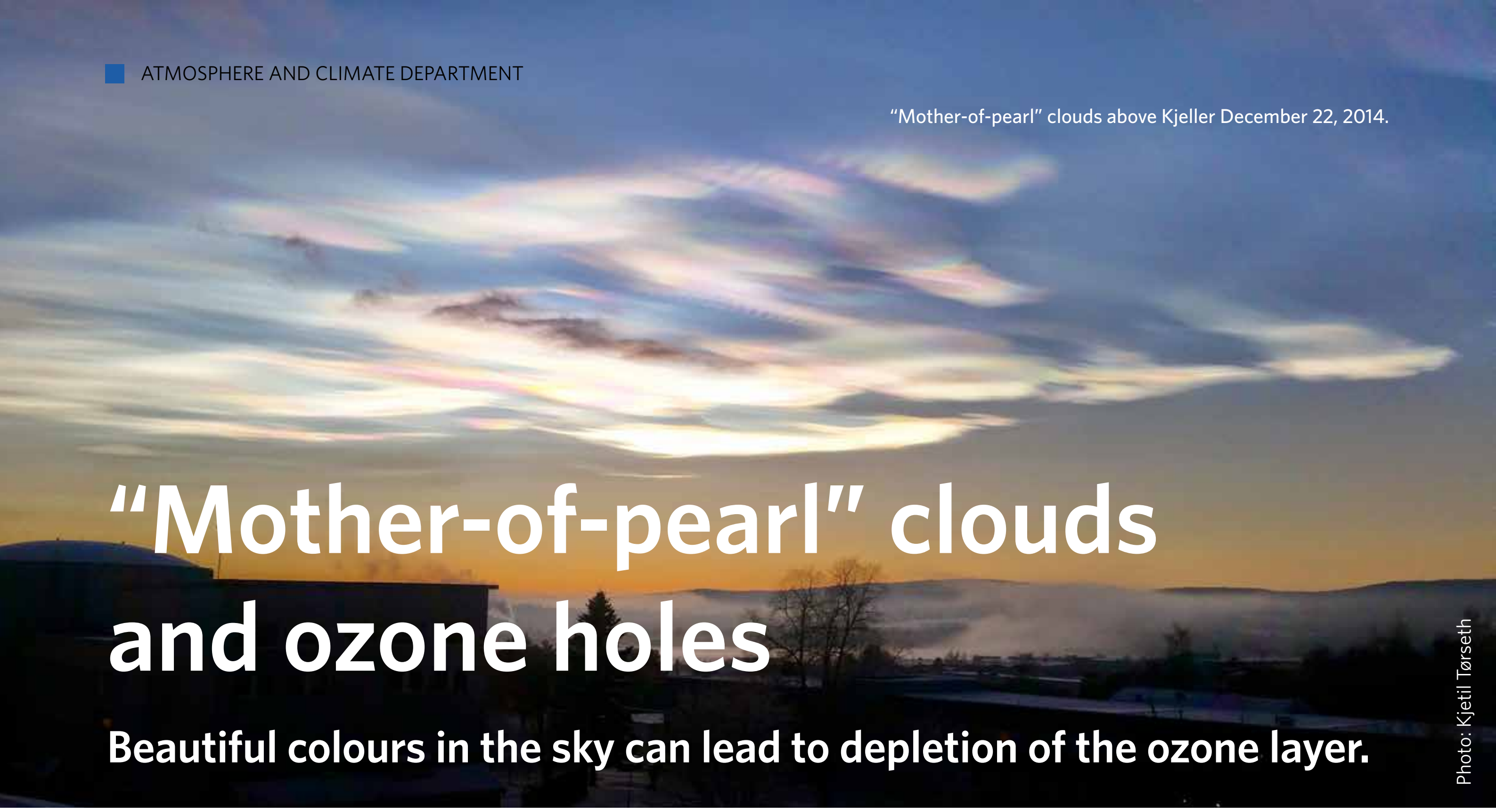
Chinese expansion for the forecasting system?

The Chinese government has decided that all the capital cities in the provinces must provide air quality information and air quality forecasting to the citizens. Hence, NILU is discussing the possibility of introducing the modelling system developed for AQ forecasting and AirQUIS as a management tool to other cities in Hubei, and looking forward to expanding their activities in China.

Web site: http://hubei-aq.info/

Satellite photo over Wuhan.

Foto: Wikipedia Commons/NASA



“Mother-of-pearl” clouds above Kjeller December 22, 2014.

Photo: Kjetil Tørseth

“Mother-of-pearl” clouds and ozone holes

Beautiful colours in the sky can lead to depletion of the ozone layer.

Tove Marit Svendby
Senior Scientist

Just before Christmas 2014, there were some beautiful clouds over the Eastern part of Norway. They are called nacreous clouds (from nacre, mother of pearl), due to their beautiful iridescent colour, and are located high up in the atmosphere. But did you know that these pearly clouds often further the depletion of the ozone layer?

Nacreous clouds are a form of so-called PSCs (Polar Stratospheric Clouds), located in heights of 15-30 km (stratosphere). This is approximately twice as high as ordinary ice clouds in the troposphere (up to 15 km). They are usually seen during the winter in Polar Regions. Since nacreous clouds are found at such high altitudes, sunlight hits them from below during sunrise and/or sunset. The ice crystals break the sunbeams like a prism, resulting in an impressive spectrum of colours.

Historic observations

Systematic ozone measurements started in Norway back in the 1930s, first in Tromsø and some years later at Dombås. Meteorologist Kaare Langlo, responsible for the Norwegian ozone measurements in the 1940s, discovered that the formation of nacreous clouds was often connected with low ozone levels.

Langlo did not find a good explanation of this phenomenon, but concluded in a publication in 1952: “We have found justifications for publishing these preliminary results in the hope that they may be of some value for continued research in this field”. Langlo’s observations were the result of “heterogeneous ozone depletion”, but several decades would pass before this phenomenon was scientifically explained.

Nacreous clouds + chlorine = ozone holes

The formation of nacreous clouds requires low temperatures (below -80°C) in the stratosphere. Such ice clouds occur fairly rarely over the Arctic, whereas they are considerably more common over the Antarctic. They are also an important reason for the massive depletion of the ozone layer (ozone hole) which occurs each spring over the Antarctic.

The atmosphere contains both natural and anthropogenic chlorine compounds. Our use of CFC-gases (chlorofluorocarbon, i.a. from spray cans) has contributed to a significant increase of chlorine compounds in the stratosphere over the last decades. Chlorine compounds are initially stable and react with ozone only to a small degree. However, chemical reactions between passive chlorine compounds on the surface of PSCs (nacreous clouds) lead to the formation of chlorine gas (Cl2).

Darkness covers Antarctica between June and August. But as soon as the sun peeks out in September, the sunlight splits Cl2 into Cl radicals that attack and break down ozone. At the same time, the polar vortex over the Antarctic (a persistent, large-scale cyclone, circling the Polar Regions and reaching from the troposphere into the stratosphere) prevents the ozone rich air from lower latitudes reaching the Antarctic. Thus, the ozone hole is a fact. At the end of November, the polar vortex usually breaks up, and the ozone hole once again fills up with ozone rich air from the equator.

Smaller ozone hole over the Arctic than over the Antarctic

In order to form stratospheric ice clouds (nacreous clouds), it must be extremely cold in the stratosphere. Due to topographic differences in the Northern and Southern hemispheres, the stratosphere is usually warmer over the Arctic than over the Antarctic, and the polar vortex there less stable. Because of this, there rarely occur as powerful and long lasting ozone holes over the Northern hemisphere.
The winter and spring of 2011 was an exception, however – at the time a long lasting ozone hole was observed also over the Northern areas. This was due to an unusually cold stratosphere over a period of several weeks, in addition to a low supply of ozone rich air from the Southern latitudes.

Nacreous clouds and climate

Due to increasing CO_2-concentrations, the troposphere will warm up, whereas the temperature in the stratosphere is expected to decrease. This may lead to a more frequent occurrence of nacreous clouds, and to ozone holes becoming more common over the Arctic. The climatic interactions are many, and future mother of pearl clouds are difficult to predict. Ozone hole or not – these colourful clouds are an impressive spectacle followed with great interest by both scientists and others with a sense of beautiful natural phenomena.

Research on aerosols to improve the prediction of climate change models

Aerosols are one of the factors influencing climate change. Thus, NILU scientists wanted to find out more about aerosols, in order to make more precise predictions about climate change.

Sonja Grossberndt
Scientist

Aerosols consist of either fine solid particles or liquid droplets, suspended in air or gas. The higher the particle number within a cloud, the more condensing water vapour is distributed over more particles. This makes the cloud turn whiter and persist longer than usual. This process cools the temperature on the earth's surface, by reflecting more sunlight before it can reach the ground.

Creating clouds

In order to find out more about this effect, NILU scientists use special instruments to create their own clouds at the Birkenes Observatory. Observing them, the scientists expect to find out more about the particles themselves and the effects they can have on the climate. By counting the number of particles that are able to form cloud droplets, climate models can be tested and improved in order to obtain more accurate climate predictions.

– The highest uncertainty for the prediction of climate is the fact that we don't have any climate data from before the industrialisation phase, explains NILU's senior scientist Markus Fiebig.

– In order to find out to what extent climate change processes have been accelerated by human activities, we have to look at areas that are still relatively clean. One of these regions is Central Antarctica.

The cleanest place on Earth

The air in Antarctica is cleaner than in any other place on earth, due to the lack of pollution from local sources. This is why NILU scientists carry out a variety of tests, to find out more about size distribution and optical properties of aerosols in the air.

These characteristics are important, since they describe the direct effect of the aerosol on climate. The results showed that the natural aerosol here undergoes an annual cycle, which can be a reference process for climate models to better represent natural processes in the atmosphere.

Measuring nanoparticles in the air

While doing their research on aerosols, Fiebig and his colleagues also discovered that gasses from the mid-latitudes and the tropics reach the central Antarctic regions in high altitudes. On their way, sunlight oxidises the gasses, resulting in the formation of new particles. Although these particles are very tiny, with a size between 30 and 100 nanometer (one billionth of a meter), they can still be measured in air samples.

Fiebig and his colleagues used data obtained from the Troll Observatory at Queen Maud Land in the FLEXPART model to find out about the origin of particles observed at Troll Station, but whose origin could not be localised before. Further modifications of the model are now envisaged to allow prognoses of future distribution of emissions.

About SACC

These research activities are part of a project called *SACC – Strategic Aerosol Observation and Modelling Capacities for Northern and Polar Climate and Pollution*. The aim of SACC is to improve NILU's competence regarding atmospheric aerosols in its core areas; air quality and climate change in the polar areas. It is funded by the Norwegian Ministry of Climate and Environment over the period of 2011-2015.

Photo: Chris René Lunder

NILU's Observatory Trollhaugen in the Antarctic.

Photo: Stein Manø

Mapping Norwegian air quality

NILU and MET Norway collaborate on a national project for the development of open source tools for mapping local air quality in Norway. The first phase runs from 2014 to 2016, and by the end of 2016 new tools and information on air quality throughout Norway will be available.

Christine F. Solbakken
Head of Communications

– The open air quality mapping tool is intended for use by national environmental authorities, researchers and air quality consultants. It is designed to help solve various air quality mapping tasks as prescribed by current legislation on local air quality, explains research director for NILU's department for Urban Environment and Industry, Leonor Tarrasón.

Based on a request from the Ministry of Climate and Environment (KLD), the Norwegian Environment Agency, the Norwegian Public Roads Administration, the Norwegian Directorate of Health and the Norwegian Institute of Public Health identified seven main tasks that according to Norwegian legislation require air quality mapping. NILU and MET Norway were entrusted with the task of retrieving the required input data and conducting the first phase of the mapping project, due by the end of 2016.

Broad mapping scope

The project will develop maps that can be used to solve the most important tasks required by current law and regulations for local air quality:

1. **Annual air quality status maps** of the geographic extent of air pollution in main cities and agglomerations
2. **Air quality zone maps** in accordance with existing T1520 regulations
3. **Scenario projection maps** of the geographic extent of air pollution in main cities and agglomerations for future years
4. **Control measures maps** to assess the impact of control plans and programmes to reduce air pollution as requested by the regulations in Norwegian cities
5. **Source allocation maps** to establish the contribution of different emission sources to air pollution levels
6. **Forecast air quality maps** with information on air pollution forecasts to inform the public about breaches of alarm thresholds, and support the implementation of short-term measures to prevent air pollution episodes in main city areas
7. **Health exposure maps** for air quality indicating the number of people exposed to harmful levels of air pollution in Norwegian cities and agglomerations

The open source tool should provide results at three levels – for the whole of Norway, for the seven largest cities and for selected towns and agglomerations. In the first phase, the focus is on generating maps showing the annual status, air quality zones, source allocation and health exposure maps. In the next phase, the project will work to establish different interactive tools based on the information gathered in the first phase.

Improved air pollution information

Currently, information on air pollution measurements throughout Norway is available via luftkvalitet.info. Forecasts on air quality are available for nine cities through the Better City Air project. Mapping information as required by legislation is only available sporadically for a few cities.

Tarrasón explains that the main reason why there is so little mapping information about air quality in Norway, is a lack of data on air pollution emissions and meteorological conditions throughout the country. Consistent emission inventories on pollution sources and fine resolution meteorological data over the whole of Norway are necessary to achieve reliable maps. Thus, NILU and MET have identified that the first priority in the development of the new national mapping calculation tool is to ensure the systematic acquisition of necessary input data for meteorology and emissions, and to establish the procedures that will guarantee regular updates of these data for the foreseeable future.

On track

At the beginning of 2015, the project was on track. The first deliveries included a report with recommendations for data flow and a desirable IT solution. The project has engaged the company NetLife Research to assist in the development of the website for the open mapping tool. NetLife Research will also consider a redesign of luftkvalitet.info, Tarrasón says.

In addition, the scientists have worked systematically to identify emission sources of data for the seven Norwegian cities and 100 villages to be included in the project, and begun the job of creating operational meteorological forecasts for Norway. They also have developed various approaches for mapping pollution conditions in both the cities and the agglomerations.

– We are in close dialogue with our users to ensure further progress, Tarrasón concludes, – and we also have the great advantage of our good relationship and synergies with the forum for Better City Air led by the Norwegian Environment Agency and the Norwegian Public Roads Administration.

Is Carbon Capture and Storage (CCS) installation the key technology to reduce CO_2 emissions from energy production?

Reducing CO_2 emissions to the atmosphere is one way of combating the effects of global warming on the atmosphere, and thus limiting the consequences of climate change on ecosystems and human health

Jozef M. Pacyna
Research Director

Amongst the various technologies researched today on the subject of CCS are those for improving combustion efficiency, as well as those aiming to reduce CO_2 from flue gases, often called CCS technologies. Nowadays, modern high-efficiency power plant boilers are expected to be CO_2 capture ready, i.e. have enough space for a CO_2 capture unit.

CCS in energy production

During the last decade, NILUs Department of Environmental Impacts and Economics (IMPEC) has been involved in studying technological, environmental, and socio-economic aspects of CCS implementation in the energy production sector.

In a project with Polish partners for the Polish energy group TAURON, it has been concluded that one of the major technological problems related to the implementation of CCS technology in power plants is the high energy demand for separation of CO_2, thus reducing the overall efficiency of energy production.

Current research is directed towards optimizing the integration of CO_2 capture systems with the technological structure of combustion processes in a power plant.

New CCS-ready technology

IMPEC, in cooperation with IFE (the Institute for Energy Technology at Kjeller) and Polish partners, is also involved in the development of a new, CCS-ready technology for coal and biomass combustion, with implementation of a chemical looping combustion concept.

Chemical looping combustion (CLC) is a process that can be characterized by the lack of direct contact between air and fuel during fuel combustion. The novelty is that the oxygen needed for fuel combustion is supplied by solid oxygen carriers, without the fuel coming into contact with air. Thus, CO_2 emissions are much reduced compared with the standard combustion process. Since the CLC concept does not require an energy demanding separation process, the technology is assumed to be more cost efficient than other CCS technologies. The project is expected to provide innovation and more understanding of the CLC processes.

More information on this project is available on www.newloop.eu.

One of the most challenging issues of CCS implementation is developing areas were CO_2 can be safely stored after separation from flue gases. Storage stability is also an issue to consider. IMPEC, together with the research institute Tel-Tek and Polish partners has just started the PRO_CCS project on economically efficient and socially accepted CCS/Enhanced oil recovery (EOR) processes. The concept of this project is based on the potential for environmental and economic benefits from integration of CO_2 emission sources and CO_2 consumers. The CO_2 from major emission sources can be utilized to improve oil recovery. The project focusses on application of CO_2 emission streams from industrial sources (refinery and other chemical plants) in the northern part of Poland, to improve recovery of oil and gas from fields in the Baltic Sea. More information on the PRO_CCS project is available on www.itc.polsl.pl/pro_ccs.

More demonstration needed

The various projects carried out at IMPEC, in cooperation with other research teams, concludes that CCS installation is the key technology for removal of CO_2 from flue gases from power plants and other industrial sectors, in order to achieve the CO_2 emission reduction targets defined in various EU Directives.

However, these installations need to be verified in full industrial scale. Thus, more demonstration projects are needed in order to prove the proper operation of the CCS concept.

Photo: Shutterstock

Searching for contaminants in Norway

Our modern life is, for better or for worse, based on the use of a variety of different man-made chemicals. Few of us want to miss out on the advantages these provide – but do we know enough about the disadvantages? For more than ten years, NILU has assisted with identifying environmental contaminants in Norway.

Martin Schlabach
Senior Scientist

The positive and desirable effects of these chemicals, whether they are constituents in pharmaceuticals, personal care products, packaging, building materials or electronics, must however always be weighed against any negative impacts on environment and health. This balance should as far as possible be based on scientific arguments that take environmental and health aspects into account, and far less on emotions or economic guidelines.

Supplement for monitoring

NILU contributes to this scientific assessment by modelling environmental fate and effect studies, in particular with the monitoring of the occurrence of these substances in the environment. Monitoring chemicals is very resource intensive, and thus continuous monitoring of the environment is only possible for the high-priority substances. To complement this full-scale monitoring, the environmental authorities in the Nordic countries have established so-called "screening" investigations.

Screening provides a snapshot of the less investigated chemicals in Norway. This kind of survey is often limited, but still important for examining the characteristics of or risks from "new" substances or groups of substances. It is often performed in places where one would expect a high incidence of the chemicals in question.

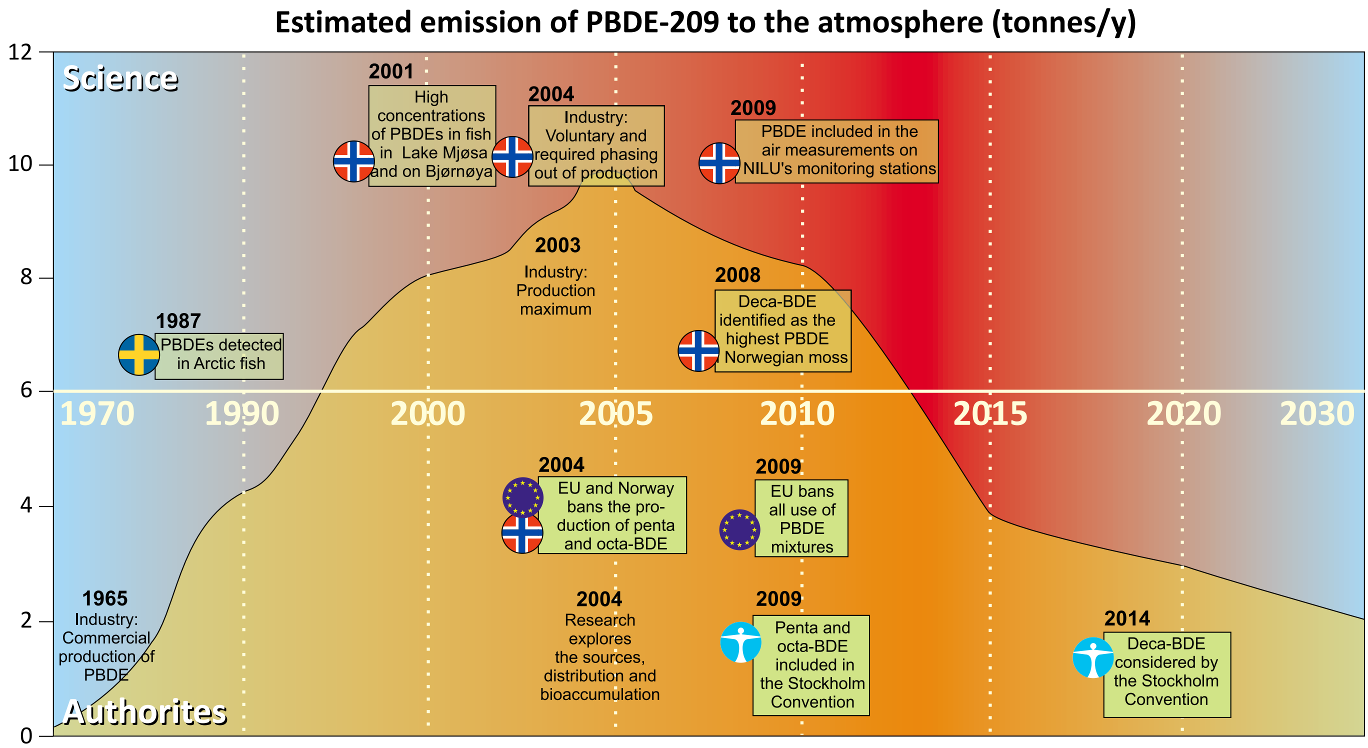
Basis for further monitoring and international agreements

This screening is also important to obtain data that says something about whether the compound poses a problem for the environment, and whether further investigation (possibly long-term monitoring and measures) is necessary. In addition, such data are important tools in devising international agreements, conventions and risk assessments.

These data have also made important contributions to understanding the substances' persistence and potential for long-range transportation with air and ocean currents. In addition, screening surveys have played an important part in Norwegian and EU risk assessments and negotiations on international agreements, such as the Stockholm Convention under UNEP POPs. As shown in the figure below, brominated flame retardants like PBDE is a typical example of such interaction between research institutes and regulatory authorities.

Which substances are screened?

The range of substances chosen for screening has been based on both the administrative authority's internal needs and priorities, and on a factual evaluation of reported consumption from manufacturers, correlated with data about the level of danger (persistence, bioaccumulation and toxicity).



Estimated PBDE emissions to air, in relation to screening studies and subsequent adjustments. PBDE screening in fish from Lake Mjøsa and Bear Island in 2001 initiated several major monitoring and research projects, which contributed significantly to a gradual phasing out of PBDEs.

The screening of contaminants has included compounds such as brominated flame retardants (PBDEs, HBCDD, TBBPA), bisphenols (for example BPA), chlorinated paraffins, siloxanes, and selected compounds in pharmaceuticals, cosmetics and biocides. The studies have sometimes been nationwide, but have mainly been concentrated on a few localities.

Research challenges, cooperation and dialogue

Screening studies are, and have long been, very strategically important for the Department of Environmental Chemistry (MILK) at NILU. The analytical challenges are usually at the cutting edge, and it is often necessary to develop new methods of analysis in a very short time. MILK has conducted most such projects in a strategic partnership with the Norwegian Institute for Water Research (NIVA), and at times also the Norwegian Institute for Nature Research (NINA), to fully exploit complementary expertise in sampling and analysis of substances.

Screening is demanding and resource intensive. To get the best possible benefit, it is important to perform long and thorough planning of all sampling, analysis and evaluation procedures. This is only achieved through close dialogue with the customers.

Facts

- **PBDE:** Collective term for a variety of brominated flame retardants, organic compounds containing bromine. Brominated flame retardants can have serious effects on both human health and the environment, since they are transported over long distances by ocean and air currents, remain in the environment for a long time, may bioaccumulate and are toxic.
- **HBCDD:** The brominated flame retardant Hexabromocyclododecane is persistent and very bioaccumulative. HBCDD is also highly toxic to aquatic organisms. The substance is classified as environmentally harmful and may possibly be detrimental to fertility.
- **TBBPA:** Tetrabromobisphenol A is another brominated flame retardant, and is classified as environmentally harmful.
- **BPA:** Bisphenol A is used in many different products, such as plastics, paints and adhesives. The substance is an endocrine disruptor, and are suspected of damaging reproductive performance, but degrades relatively easily in water and is not very bioaccumulative.
- Source: Miljøstatus.no

PhD students at ATMOS in 2014

From left, Andreas Vogel, Sofia Eirini Chatoutsidou and Jonas Gliß.

Sofia Eirini Chatoutsidou comes from Greece, and has been working on her PhD project at NILU for two years. Her project, *Human Exposure to Aerosol Contaminants in Modern Microenvironments (HEXACOMM)*, is funded by the Marie-Curie Actions: Initial Training Networks.

As most people spend around 80-90% of their time indoors, indoor air quality has become a major issue during the last two decades. Thus, Chatoutsidou wants to find out how our activities at home affect particle characteristics indoors, as well as how outdoor particles affect indoor air quality. Currently she is examining what kind of physical processes makes particles that are already deposited on indoor surfaces. Knowing where particles come from and what they are made of is important to health assessment, especially for vulnerable groups (elderly and children).

Andreas Vogel is a German Early Stage Researcher at ATMOS and started his PhD project in May 2014. His current research project is also funded by the Marie Curie Actions: Initial Training Networks, and is titled *Volcanic ash: Field, experimental and numerical investigations of processes during its lifecycle (VERTIGO).*

The eruption of the Eyjafjallajökull volcano on Iceland in 2010 showed that drifting volcanic ash clouds affect aviation and air traffic on a regional and global scale. The major concern about volcanic ash particulates in the atmosphere is that they can cause serious damage to aircrafts. Vogel studies how ash particles behave in both the atmosphere and the aero engine. This involves numerical experiments using high-resolution computational fluid dynamics (CFD) modelling of aero engines, as well as detailed investigations of particle characteristics and how they act during transport in the atmosphere and the engine.

Jonas Gliß is a German PhD student. He started his project on the study of volcanic emissions in April 2014. Active volcanoes can release large amounts of gases, such as water (H_2O), carbon dioxide (CO_2) and sulfur dioxide (SO_2) into the atmosphere. It is well known that these gases influence atmosphere and climate, both on regional and global scales (e.g. ozone depletion or acid rain). In order to determine these impacts, Jonas uses and further develops state of the art optical measurement techniques to study the chemical composition and the evolution of chemical species in volcanic plumes. Moreover, current studies show that the data gathered with these modern measurement techniques might even be suited to address questions related to volcanic risk assessment and volcanic activity (i.e. eruption prediction).

Henrik Grythe researches the transport of aerosols in a Nordic collaboration project, *Cryosphere Atmosphere Interactions in a Changing Arctic Climate (CRAICC).*

Aerosols are often referred to in the media in connection with air pollution from traffic in cities, but they are also a major influence on cloud formation and climate. Grythe uses a model that describes the transport of these particles in the atmosphere and looks at the resulting particle density in areas with existing air quality measurements. By comparing particles from measurements and the model, we can improve our understanding of where the aerosols come from, how they move and where they go. An important aspect of the project is the sharing of expertise between the Nordic countries. Grythe's time is therefore divided equally between NILU at Kjeller, ACES in Stockholm and FMI in Helsinki.

Are nanomaterials safe to use?

Nanomaterials are everywhere around us. You find nanomaterials in a broad range of materials from sport clothes, cosmetics, toothpaste, painting, building materials and electronics to pharmaceuticals. Moreover, as rapid progress within nanotechnology continues, more products enter the market.

Elise Rundén Pran
Senior Scientist

The unique properties of nanomaterials, and what make these products useful, are linked to the nanoscale.
One nanometer is one billionth of a metre – and nanoparticles are defined as particles between 1 and 100 nanometres in size.

Size really matters

It is the nanosize that enables the particles to cross barriers in the body (e.g. the blood brain barrier protecting the brain), and this feature has revolutionized nanomedicine for diagnostics and treatment.

Further, nanomaterials can be designed, combined and manipulated to achieve the desired properties, e.g., by surface coating and change of size. But how can we be sure that nanomaterials only do what we desire them to do? Could nanomaterials also have unintentional effects that could be hazardous to humans or environment?

Testing toxicity

To prevent hazardous effects on humans or the environment, it is essential to test the potential toxicity of the nanomaterials. However, there is a knowledge gap between nanotechnology and nanotoxicology.

The Health Effects Laboratory at NILU has great expertise in the field of nanotoxicology, and applies a battery of in vitro tests (testing in cell cultures in dishes instead of in animals (*in vivo*)) adapted for toxicity testing of nanoparticles. This is in accordance with the Regulation on Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) to "reduce, refine and replace" for minimizing the use of animals in research.

Standard tests generally have to be modified and validated to ensure the nanoparticles do not interfere with the test assay, as the small size gives a large surface and thus a very high reactivity. What makes this field so interesting, but also so challenging, is that toxicity is highly dependent upon both the size of the nanoparticles as well as the surface coating.

To avoid completing a development process for a new nanomaterial with desired features and finding out in the end that it is highly toxic, development and toxicity testing should in general be performed in parallel. This "safe-by-design" approach will save both time and cost.

Narrowing the knowledge gap

The Health Effects Laboratory continues to explore the field of nanotoxicology further, to contribute to narrowing the knowledge gap and ensure nanosafety – the safe use of nanomaterials.

Validation and standardization of tests methods is very important, and we are involved in many international and national projects within this area. Especially for this work, it is of great advantage that the Health Effects Laboratory is certified by the Norwegian Accreditation body according to the OECD´s principles for good laboratory practice (GLP) – currently as the only GLP certified laboratory for in vitro human toxicity testing in Norway.

Web site: Health Effects Laboratory

Expertise

Scientists from many different disciplines work at the Health Effects Laboratory (HEL): toxicology, genotoxicology, cell biology and biophysics. HEL is at the frontier of research, having published more than 70 peer-reviewed articles since 2006.

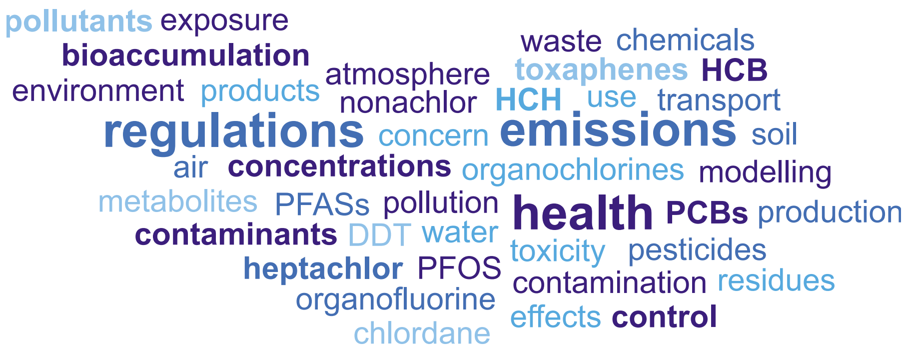
HEL is one of 15 European Transnational Activity centres, the best institutions in Europe containing appropriate facilities and expertise within the field of nanotoxicology. The laboratory is also popular amongst scientists applying for travel grants and access within the EU-FP7 research infrastructure project QualityNano, due to both the GLP certification and methods as well as expertise and facilities. HEL was the second most attractive host, providing 21 visitors with almost 400 days of access.

Photo: Shutterstock

The Tromsø Study: 54 men, 51 chemicals and 28 years

Unique data shows that regulation and ban of environmental contaminants really works.

Christine F. Solbakken
Head of Communications



In the context of a population study in Tromsø, 54 men have delivered 5 blood samples during the period 1979-2007. These samples were of great help to describe time trends of 51 environmental contaminants and their relationship to the trends in use and emissions of the same contaminants.

Scientist Therese Haugdahl Nøst wrote her PhD based on the so-called Tromsø Study, and tells us that the intention of her work was to gain more understanding about how the amount of environmental contaminants in the human body changes over time. Through repeated measurements of serum samples, which are rare in this context, Nøst and her colleagues could determine time trends for a number of different environmental contaminants in individuals over a period of almost 30 years. Such extensive and lengthy data is unique, and provided the scientists with lots of new information.

PCB-levels decreased

One group of environmental compounds the scientists were looking for in the samples was the so-called PCBs (Polychlorinated biphenyls). PCB is a collective term for a group of industrial chemicals developed in the 1920s, and used in building materials and electronic devices until their ban in 1980.

Nøst says that she found PCBs in all the oldest blood samples from 1979, whereas the concentrations were already decreasing in the samples from 1986. This suggests that the environmental concentrations also must have decreased after the ban came into effect.

– Several studies about environmental contaminants conclude that the concentration of these compounds increases in the human body with advancing age, explains Nøst. – These studies are cross-sectional studies, whereas in our longitudinal study the concentrations only increased with advancing age when emission and use were also increasing or steady. Furthermore, concentrations decreased when emissions ceased; this implies that the body continuously strives to remove these chemicals from our body.

Photo: Shutterstock

The role of historic use

In contrast, the concentration of some PFAS (per- and polyfluorinated alkyl substances) increased between 1979-2001, when emissions were reduced, and then decreased again towards 2007. Levels of other types of PFAS have been increasing during the whole time of the study.

– Changes in this period have varied for different environmental contaminants, says Nøst, – but our findings show that the concentration of environmental contaminants in humans changes with the use of the compound – and the amount found in our environment.

To summarize, the time trends studied by Nøst show that when interpreting the concentration of environmental contaminants in humans, one also has to take into account the timing of the study in relation to production and use of each specific compound.

See also the article about Therese Haugdahl Nøst's PhD on page 22.

A journey with the Port of Oslo

Photo: The Nguyen Thanh

PortsEYE maps air pollution emissions from the Port of Oslo.

The Nguyen Thanh
Senior Adviser

In 2014, PortsEYE undertook a project for the Port of Oslo, where the objective was to conduct a detailed survey of air emissions from the Port. Senior scientists Dag Tønnesen and Susana Lopez-Aparicio from NILU contributed core expertise on local air quality in port operations, and in addition, model calculations were performed to identify various measures on how the Port can optimally reduce their air pollution.

After completion of the project in December 2014, the Port has a detailed overview of their air emissions for 2013. They can share this overview with their partners, implementing the various environmental measures to reduce air pollution. In addition, environmental manager Heidi Neilson at the Port of Oslo has gained insight into a useful framework for harbour air quality management, which she wants to share with other ports in Norway.

Crucial

In connection with the project "Measures study of air quality in Oslo and Bærum 2015-2020", organized by NPRA and the municipalities of Oslo and Bærum, air emissions information from the Port has been crucial to get a total and updated image of the air emissions from Oslo and Bærum in 2013.

The project has posed various challenges, especially during the mapping, information gathering and validation phases. The Port's value chain involves many actors, and it is complicated for outsiders to gain insight into it.

Still, the Port has rendered invaluable assistance throughout the process, thanks to the ever-enthusiastic environmental manager, Heidi Neilson. Neilson's contact with relevant sources of information has been crucial for the implementation of the project, as have the contributions from all the skilled professionals working in the Port.

Competence and enthusiasm

In hindsight, we see that there were many critical factors during the project implementation that could have affected the delivery in a negative way. However, good teamwork, enthusiasm and open communication kept the project going and resulted in a solid performance.

Our journey with the Port of Oslo has been both exciting and instructive, and definitely left us ready for more.

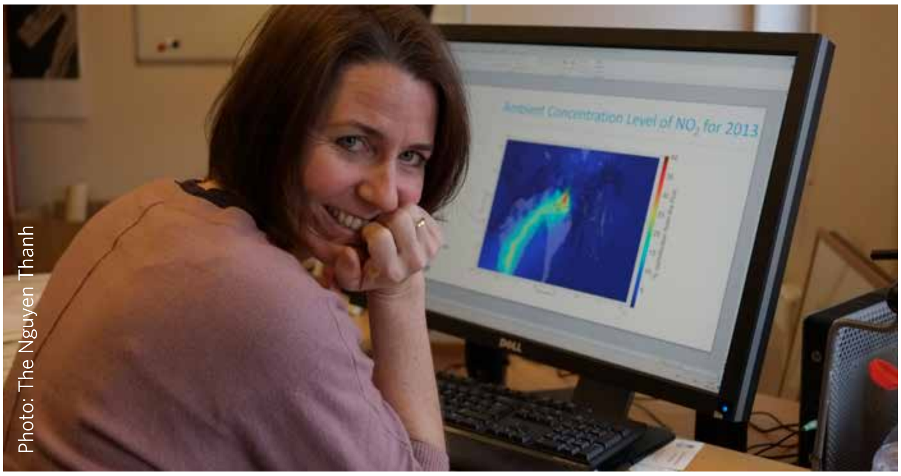


Photo: The Nguyen Thanh

– PortsEye was an important contributor to our understanding of how sea transport and traffic into the port affect the air quality in the city of Oslo, says environmental manager Heidi Neilson. – The project resulted in a specific baseline, with emission data in metric tons per year. This is an important starting point for our future work on what we can do to help improve the city air.

PortsEYE

PortsEYE is a highly specialised company developing technologies to identify SO_2 and other compounds in the air.

The technologies the company develops come from research conducted within NILU – Norwegian Institute for Air Research and will focus on supplying monitoring technologies and services to both the maritime, industrial and environmental protection markets.

Web site: http://portseye.com.

National Air Quality Reference Laboratory: Equal measuring throughout Europe

For mapping and comparing air pollution levels throughout the EEA, all monitoring stations of the same kind must follow the same standards of quality and traceability with regard to calibration and procedure. NILU ensures this for Norway.

Christine F. Solbakken
Head of Communications

In 2001, NILU was appointed the National Air Quality Reference Laboratory (NRL-Air) for Norway. As reference laboratory, NILU ensures that all air monitoring data collected through the programme Air Quality Monitoring in Norway are of high quality, and comparable with similar data from other countries in Europe.

Quality and traceability

Work is performed in accordance with the EU Air Quality Directive 2008/50/EC, and in accordance with Norwegian Pollution Regulations. Requirements of representativeness and traceability are met through the use of a comprehensive quality control system, developed by NRL-Air and complied with by the Norwegian measurement networks monitoring local air quality.

– The control system includes a description of how to maintain and calibrate the various instruments, both in the field and in laboratories, explains Kjersti Tørnkvist, Department Director of NILU's department for Monitoring and Instrumentation Technology. – This is to ensure that all the instrument operators perform the various tasks in the same way.

Ensuring comparable data from all measurement networks requires a traceability system, to guarantee that all air quality measurements in Norway perform according to the EU Air Quality Directive and common national reference standards. These reference standards are maintained by NRL-Air, and are internationally traceable due to NRL-Air routinely participating in international comparison campaigns.

– To coordinate instrumentation and methods across national borders, the reference laboratory is a member of international fora such as the European Committee for Standardisation (CEN) and AQUILA, the European association of national reference laboratories, Tørnkvist says. – In March 2015, we participated in an intercalibration campaign for particles (PM_{10} and $PM_{2,5}$) in Ispra, Italy. We will also attend an intercalibration campaign for NO_X, O_3, SO_2 and CO in October 2015, to check our equipment.

Measurement station Tiller, Trondheim.

Photo: Claudia Hak

All over Norway

Norway's air quality measurement network consists of 52 monitoring stations – counting only stations reporting measurement data on at least one parameter to the EEA/ESA (EEA: European Economic Area, ESA: EFTA Surveillance Authority).

In 2014, the reference laboratory did a review of all the station locations. Researchers from NRL-Air did this by visiting every station, to verify that the location and classification followed the specifications in the EU directives. In addition, they listed proposals for adjustments – such as removing trees around the station to ensure free flow of air to the instruments.

This review is published as a report, *Norges målenettverk for luftkvalitet: Gjennomgang av stasjonsplasseringer i forhold til krav i EUs luftkvalitetsdirektiver* (in Norwegian only). Interested parties can also visit the national web portal luftkvalitet.info, where up to date data and status in comparison to the pollution limits are available for each monitoring station.

Information to the public

Each month, all measurement grid operators report quality-assured data to the national database for local air quality, operated and maintained by NRL-Air. In Norway, air quality is monitored for three urban regions and four large regions – Troms and Finnmark, Central Norway, Trondheim, Bergen, Western Norway, Southern- and Eastern Norway and Greater Oslo. Norwegian reports to the EU on air quality status and compliance with established pollution limits are based on these seven zones.

The EU Air Quality Directive also requires that each country has systems to inform the public about air quality where they live. In Norway, this is mainly done via the national web portal www.luftkvalitet.info. Here, air quality information from all the 52 different monitoring stations is available, as well as the status with reference to established pollution limits.

InnoSense – a ground breaking micro sensor solution

InnoSense is a FORNY2020 commercial verification project, with a total project budget of 7 150 000 NOK – 80% of which has been granted by the Research Council of Norway.

Stian Håland
Engineer

InnoSense is a disruptive innovation: an air quality micro sensor platform that can monitor multiple compounds at a fraction of the cost of standard solutions.

The key features of the new and unique technology are size, reliability, flexibility and scalability. The dimensions of InnoSense compared to the solutions used today is 1:1000 (shoebox VS shipping container). InnoSense will also be the first micro sensor platform to provide reliable data, while measuring up to eight gases selected to match client needs. In addition to this, the systems can be networked, scaling from one to thousands of units.

The InnoSense technology enables the monitoring of air quality data at local levels. The more sensors that are distributed, connected and collecting data, the more meaningful are the results. This in turn, generates more value. InnoSense can also be integrated with large data platforms, such as those that monitor weather, traffic, etc.

The InnoSense project engages Kjeller Innovation, NILU, pilot customers and Ericsson in providing a new technology concept that boosts our ability to monitor air quality from micro- to large-scale networks across a variety of industries and customer groups. Working together, this group of inventors and partners has what it takes to make InnoSense a success.


From left; Stian Håland holding the micro sensor, Franck Dauge and Morgan Kjølerbakken.

Fact

FORNY2020 is the Norwegian Research Council's program for research-based innovation at universities, colleges, hospitals and publicly funded research institutes.

Web site: FORNY2020

EBAS: Open access to atmospheric data

Acidification provided the basis for the world's most extensive database for atmospheric composition.

Kjetil Tørseth
Research Director

Early in the 1970s, a joint European program to measure the chemical composition of air and precipitation was established. The results proved that air pollution could spread across national borders and provide negative impacts on ecosystems far from where the emissions took place. Specifically, the acidification of lakes and rivers in Scandinavia caused concern, but eventually it was also discovered that the transboundary pollution damaged vegetation, health and materials in addition to affecting the climate system.

Pioneering research

Having open access to measurement data was fundamental in legitimizing the research on transboundary pollution. It was also crucial in achieving international agreements at the Convention on Transboundary Air Pollution in 1979. This sharing of data was also groundbreaking in that it took place in a time of little contact between the Eastern Bloc countries and the West due to the Cold War.

Since the collection and sharing of data started, NILU has been responsible for coordinating the countries' measurements and gathering the results in a database accessible to a wide range of end users. In the beginning, the results were reported by completing a written form sent by letter. Designated personnel at NILU received these and punched the values into a single database.

Eventually it became more common to report the data electronically, and eventually the requirements for metadata (data containing important information about the actual results, such as the name of methods, information about the measurement location and any local influences etc.) also increased.

"State of the art" in 2014

This database infrastructure has, over almost 45, years evolved to become a primary database for a wide range of international conventions and measurement applications. The data gathered are used in a very large number of scientific publications and other background material, as a basis for the environmental management. Through the Norwegian Research Council's infrastructure program, the project EBAS-Online, has been given the opportunity to develop the database further, so that it today represents the "state of the art" within atmospheric research.

In the fall of 2014, a revised database was made available. NILU now receives data from more than 50 countries and about 300 stations/observatories. More than 400 different chemical and physical variables measured with more than 70 different types of instrument are reported. Each month, there are over 700 individual users of the database, and EBAS also constitutes the most comprehensive database of atmospheric composition on an international level.

E-reporting of air quality data

In the framework of a pilot project, the European Environmental Agency (EEA) has engaged several countries, amongst them Norway, to develop XML-forms (Extensible Markup Language) and exchange mechanisms for electronic reporting of air quality data.

Rune Åvar Ødegård
Head of Development

Each year, data related to zoning, monitoring regime, monitoring methods, "near real time data", aggregated data and statistics will be reported to the EEA. Information linked to the achievements of environmental goals, together with plans and measures about how to stay within limit values, is also gathered.

In addition to the need for one common electronic reporting system, the solution has taken into account the requirements for INSPIRE compatibility. The purpose of the INSPIRE directive (Infrastructure for Spatial Information in Europe) is to establish an infrastructure for publicly administrated geographic information (geo data), which shall in return enable electronic sharing of data between public authorities linked to tasks that can affect the environment.


Satellite photo of Europe at night.
Photo: Wikipedia Commons

The vision of the directive is:

- Data will be collected once and stored as effectively as possible
- It will be possible to easily search for and combine geographic information seamlessly from different sources from all over Europe
- Information sharing between different users and applications is possible

NILU's responsibility in this e-reporting project, funded by the Norwegian Environment Agency, is to develop Norwegian web services that can report air quality data to EEA. Norway was one of the first countries to develop a long-term solution, and has since been actively participating in the process. This in return has resulted in a stronger position for Norway in the European collaboration about e-reporting of air quality data – with the added opportunity to influence processes and solutions to a greater extent.

Therese Haugdahl Nøst

Therese Haugdahl Nøst, NILU.
Photo: NILU

On June 25, 2014, Therese Haugdahl Nøst defended her PhD thesis at the University of Tromsø's Faculty of Health Sciences.

The thesis was entitled *Understanding temporality in human concentrations of organic contaminants: Considering human concentrations over time and through life in perspective of historic production and use.*

The overarching aim of Nøst's thesis was to enhance our understanding of how human concentrations of persistent organic pollutants (POPs) have changed in individuals over time. Five repeated measurements between 1979 and 2007 from 54 men in the Tromsø Study were used. Concentrations of most PCBs (polychlorinated biphenyls) and OCPs (organochlorine pesticides) decreased from 1979 or 1986 whereas concentrations of some PFASs (per- and polyfluorinated alkyl substances) increased from 1979 to 2001 and decreased to 2007. The time trends of POP concentrations generally display a strong link to concentrations in the environment and production and use of these compounds. Clearly, a ban in production and use of some POPs have led to decreasing concentrations in humans.

Measured concentrations of PCBs were compared with concentrations predicted by emission-based exposure modelling at both a group and individual basis in the Tromsø men and in two female study groups. The results agreed well and demonstrated the potential of mechanistic modelling as a useful tool in human biomonitoring and effect studies.

Read more about the Tromsø study on page 17

Anne Karine Halse

Anne Karine Halse, NILU.
Photo: NILU

Anne Karine Halse gained her PhD at the Norwegian University of Life Sciences' Faculty of Veterinary Medicine and BioSciences.

She defended her thesis, entitled *Long-Range atmospheric transport and deposition of organic pollutants (POPs) in North Western Europe,* at NILU on December 16, 2014.

The thesis focuses on selected persistent organic pollutant (POPs) regulated by international agreements. POPs are toxic compounds, semi-volatile and persistent in both air as well as in other environmental media, and therefore able to undergo long-range atmospheric transport. POPs may therefore deposit in remote and pristine environments (i.e., the Arctic), far away from any point sources.

A specific aim was to increase the understanding of the distribution of some legacy POPs in air, by use of a passive air sampling technique, active air samplers (AAS), and an atmospheric transport model (FLEXPART). By deploying passive air samplers (PAS) at 86 European background stations in 34 countries, Halse was able to document that the spatial variability of legacy POPs and their distribution largely reflects historical and contemporary source regions in Europe. Parallel to the European background site campaign, passive air samples were collected in rural Norwegian coastal zones that are known for elevated POP levels in seafood. By combining results from these two campaigns, it was documented that some Norwegian coastal zones are strongly influenced by local emission sources of regulated POPs. Furthermore, a model-based forecast system was developed and evaluated, to predict long-range atmospheric transport (LRAT) of emission episodes to background areas.

The thesis also assesses the occurrence and distribution of "newly regulated" POPs in soil along a transect going from UK to Norway. Levels of chlorinated paraffins (SCCPs) were high close to source regions. Endosulfans often peaked in precipitation-rich areas, and pentachlorobenzene (PeCB) correlated well with black carbon (BC). Combustion processes are believed to be a key source of PeCB. Both PeCB and endosulfans show similar spatial distribution patterns with regulated POPs.

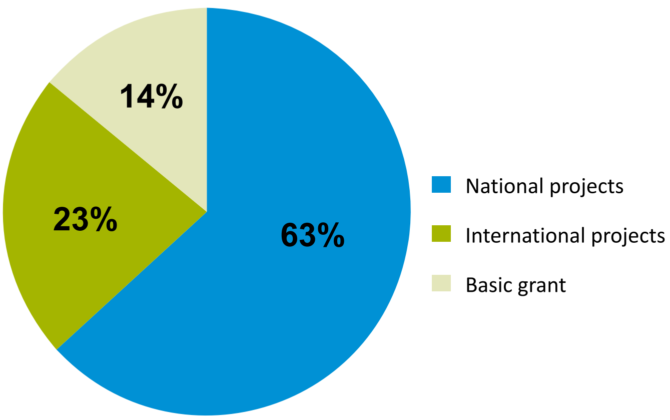
Key figures

Extract from the annual statement: All figures in MNOK

INCOME STATEMENT	2014	2013
Project revenue	152,0	160,0
Basic grant*	25,6	24,6
National tasks and grants	9,1	9,0
Other operating income	0,8	0,8
Operating revenue	**187,5**	**194,4**
Wages and social expenses	-137,2	-138,4
Direct project expenses	-23,6	-23,5
Other expenses	-33,6	37,2
Operating profit	**-6,9**	**-4,7**
Net financial items	1,7	-0,7
Tax	0,8	0,1
Profit for the year	**-4,4**	**-5,3**

BALANCE SHEET	31.12.14	31.12.13
Fixed assets	123,1	108,9
Current assets	76,1	64,6
Total assets	**199,2**	**173,5**
Total equity	115,9	97,7
Long-term liabilities	15,9	21,8
Short-term liabilities	67,4	54,0
Total equity and liabilities	**199,2**	**173,5**

PROJECT PORTFOLIO – PERCENTAGE 2014



NUMBER OF MAN-YEARS	2014	2013
Total	164	180
- whereof research man-years	94	102
- whereof man-years of other personnel	70	78
Turnover per research man-year (MNOK)	**1 995**	**1 906**

NUMBER OF EMPLOYEES	2014	2013
Total	179	198
- whereof women	90	90
- whereof men	89	108
Number of employees holding a doctorate	**71**	**65**

PROJECT PORTFOLIO - PERCENT	2014	2013
National projects	63 %	54 %
International projects	23 %	33 %
Basic grant	14 %	13 %
Total	**100 %**	**100 %**

NILU's PUBLICATIONS	2014	2013
Peer-review articles	124	121
Scientific reports	69	51
Technical reports	2	1
EMEP/CCC reports	4	5
Lectures	139	143
Posters	32	18

NILU scientists also contributed to the publication of:		
External reports	15	29
Chapters/articles in books/reports	55	39

Number and nationality of the scientists

2014: 179 employees from 25 different nationalities

2013: 198 employees from 32 different nationalities

**strategic institute initiatives included*

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