Annual Report 2015

NILU

Contents

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Front page: Majorstukrysset, Oslo.
Photo: Christine F. Solbakken.

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NILU welcomes "The green shift"!

Through 46 years of research, NILU has steadily worked towards improving the environment. In 2015, "The green shift" was coined "Word of the Year" by the Norwegian Language Council. NILU's business might well be described with by this phrase – for us, the green shift means a transition to a society where development and growth occurs within the limits of nature, and where products and services lead to less negative consequences for the climate and environment than they do today.

NILU can, and will, contribute to the necessary changes needed to fulfil the Paris agreement under the Climate Change Convention. We know a lot about what drives climate change, and about what affects the environment on scales ranging from local air to global atmospheric transport. We have extensive experience in developing the knowledge needed to find good solutions in collaboration with authorities and industry. Right now, we have ongoing projects on carbon capture and storage in China and Poland, and we are working on developing smart cities both nationally and internationally.

Horizon 2020 is well underway. The transition to a new framework program in the EU is always challenging, and H2020 is far more interdisciplinary and innovative than previous programs. Our experience so far is that NILU is doing well, and we are particularly proud to have won a large ERC research grant. Our success so far is largely due to the important efforts of the Norwegian Research Council within Stim-EU, as well as their support in writing applications and networking. It is crucial that this great initiative continue in the years ahead.

A paradox in environmental research is that the willingness to invest in environmental contaminant research is inversely proportional to both society's interest, and the seriousness of this threat. Norway has set a good example, but within the last 10 years, research funding has been reduced to a level that threatens both recruitment and skills.

Otherwise, I am happy to state that after the restructuring process in 2013/14, 2015 seems to become one of NILU's best years, both professionally and financially. The evaluation of the environmental research institutes supported this statement: NILU received praise for both scientific quality and relevance to society, in combination with high customer satisfaction in both the public and private sectors. NILU is considered highly competitive both nationally and internationally, and is recognized for its very good organization culture.

In this annual report, you can read about NILU's backbone: our monitoring and modeling, as well as samples of our international engagement and exciting news from our innovation initiative.

Enjoy your reading!

Kari Nygaard
Managing Director

NILU invites citizens to monitor air quality

New technology and new portable sensors makes it possible to monitor air quality in new ways and to a far greater extent than before. It also makes it easier to invite the general public to contribute to the research.

Christine F. Solbakken
Head of Communication

– People are becoming more engaged in air pollution and health issues associated with it, explains research director Alena Bartonova. – Thus, it is natural to invite them to help monitor the air quality in Norwegian towns, as the technology makes this possible.

Sensors all over Europe

Alena says that NILU scientists have started testing various technologies for personal monitoring. This is happening under the auspices of the joint European research project, CITI-SENSE (*Development of sensor-based Citizens' Observatory Community for improving quality of life in cities*). The project takes place in nine cities; Oslo, Barcelona, Belgrade, Edinburgh, Haifa, Ljubljana, Ostrava, Vienna and Vitoria.

The local project teams are testing several methods to communicate with the public about air pollution, with focus on utilizing the latest technological advances in sensor and IT technology. Today, it is finally possible to combine private monitoring data and observations with public information to provide an overview of the air pollution situation in near real time, exactly where you are.

Complements monitoring stations

CITI-SENSE wants to use mobile sensor technology to let you and I monitor the air quality in our neighbourhoods.

– Although the new mobile technologies offer many opportunities and have great innovative potential, there are still several challenges that must be solved, says Bartonova. – Monitoring equipment with microsensors do not yield stable data, the new technology is still somewhat uncertain in function and use. Therefore, it is difficult to directly compare data from the sensor platforms with data from the public monitoring stations, but NILU and our partners have developed a system that allows the sensor platforms to be used as a complement to the public monitoring network. So even if the information from the mobile sensors is not yet accurate, paired with data from monitoring stations it could provide a more comprehensive picture of the environmental conditions in the city. This applies particularly to areas where there are no monitoring stations.

Testing with volunteers

Scientist Núria Castell explains that the first test round where volunteers will use portable air monitoring sensor platforms in Oslo starts in April 2016.

The information gathered by the participants is made available to them via applications on their mobile phones (apps). It works by sending data from the participants' mobile sensors and phones to a common system. The system then makes the information available for everyone, along with an updated map of air pollution in the city. Furthermore, participants can



The CITI-SENSE project takes place in nine European cities; Oslo (pictures), Barcelona, Belgrade, Edinburgh, Haifa, Ljubljana, Ostrava, Vienna and Vitoria. Photo: NILU

upload their subjective perception of the pollution; how they see it.

Due to precision of the measurements the data are only made available grouped by colour, from deep green for healthy to dark brown for unhealthy, not as concentrations. Regardless, the participants get useful information in return, such as a real-time maps of the current pollution situation.

This aggregated information is made available both online and through newly developed apps. The interface – a "Citizens' Observatory" – acts as a virtual meeting place. People all over Europe will be able to use such virtual meeting places to exchange information and learn from each other. They will also get tools and training in how to evaluate and use the collected data for their own and others' benefit.

You can colour the air as well!

If you are not enrolled as a project volunteer, but still want to contribute to the research, you can use CITI-SENSE's app, "CityAir." It lets you share your personal perception of air quality where you are with other users, and with the scientists. You can "colour code" the air – from green for "very good" through orange for "poor" to red for "very bad", and you can enter information about what you think is the source of the bad air quality.

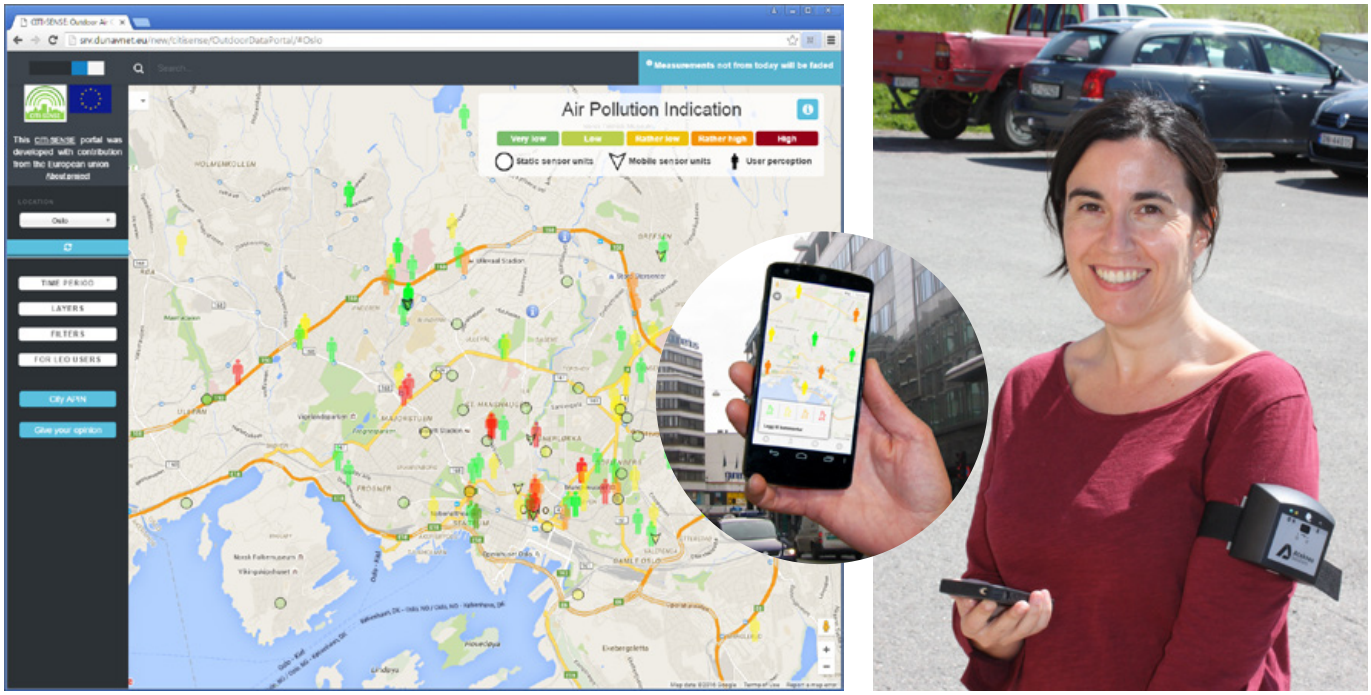
The information gathered and shared can be of particular use for vulnerable groups, wanting to i.e., avoid areas with lots of pollen or road dust. In addition, the feedback provided on the app is important for its further development.

Data collected are displayed along with other air quality information in a web solution common to all the participating cities: http://srv.dunavnet.eu/new/citisense/OutdoorDataPortal/# (until September 2016).

In order to make comparisons and see day by day development, the project has also created an air quality map for each city, based on a combination of statistical techniques based on the available emission and measurement data. Bartonova hopes that this information can help increase people's understanding of air quality, in addition to getting people interested enough to want to take part in the various processes needed to reduce air pollution in Europe enough that it is no longer harmful to our health.

Open for all

CITI-SENSE and our tools are open to everyone, not just those participating in the project. The team also invites other developers to share their tools via CITI-SENSE Citizens' Observatories platform: http://co.citi-sense.eu/.



The project offers participants different types of mobile technology, such as the app CityAir (left) and portable air monitoring sensors such as the one scientist Núria Castell demonstrates (right). Photo: NILU

Research for a clean atmosphere

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

NILU'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 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 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 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 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 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.

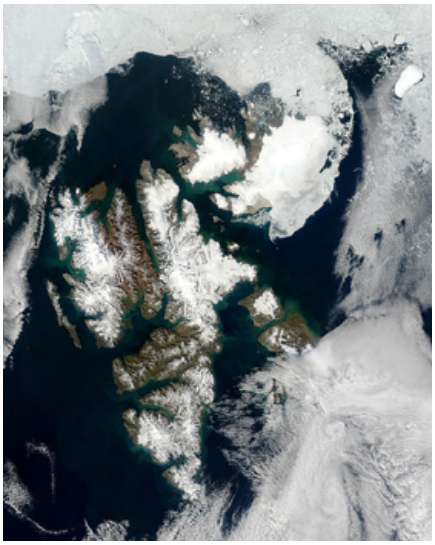
The Software and Hardware Development Department is responsible for development and maintenance of NILU's software and hardware products, from the cutting-edge AirQUIS air quality model, to project web sites and adaptation of modules and databases.

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.

In February 2015, King Harald V visited the Troll research station in Antarctica on the occasion of the station's tenth anniversary. Senior scientist Chris Lunder gave the King a tour of the "Trollhaugen" observatory. Photo: Jan Wasseng

Climate gas monitoring shows met

The observatories at Svalbard and Aust-Agder have tracked atmospheric changes vigilantly since 1989. In 2014, methane levels rose to record levels.



Christine F. Solbakken
Head of Communications

At Svalbard and Aust-Agder, NILU measures the concentration of a number of greenhouse gases in the atmosphere. These measurements are part of the program "Monitoring of greenhouse gases, the ozone layer and atmospheric pollutants," which is part of the national monitoring of pollution in Norway.

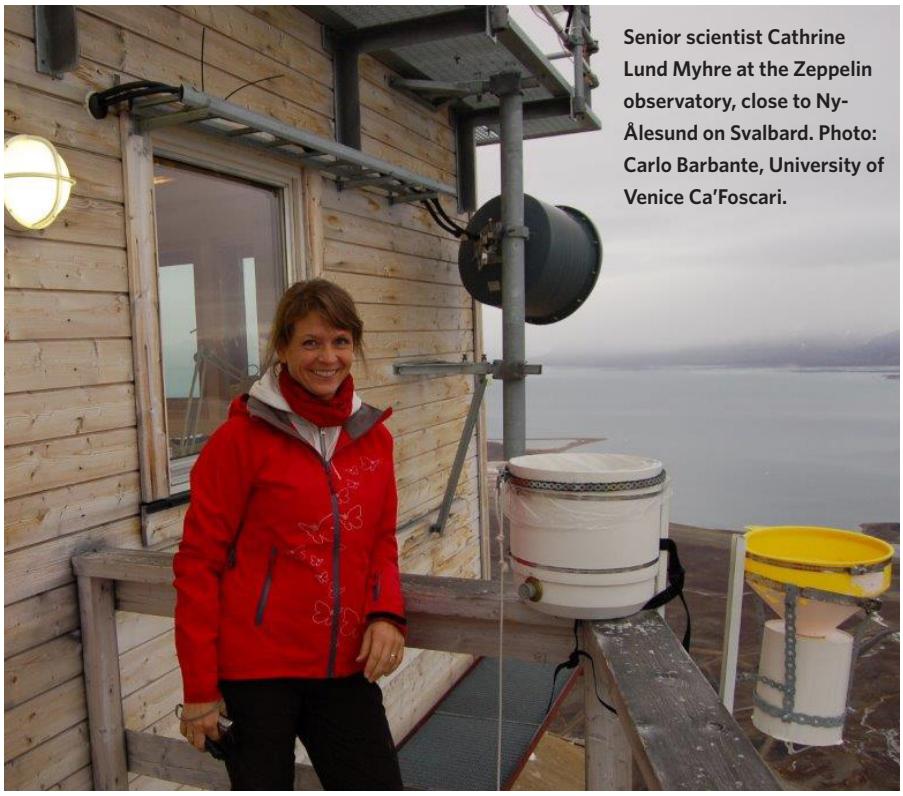
Global monitoring of greenhouse gases

Measurements from the Zeppelin Observatory in Svalbard show developments in the Arctic and the Northern Hemisphere, while the Birkenes Observatory in Aust-Agder is located in the area of Norway most affected by emissions from the continent.

The measurements are made on behalf of the Norwegian Environment Agency, and are also included in a network consisting of several global and European sites that monitor the development of greenhouse gases in the atmosphere. The observatories contribute to a number of research infrastructures and operational networks, among them the European Monitoring and Evaluation Programme (EMEP), the Advanced Global Atmospheric Gases Experiment (AGAGE) and from 2016 also ICOS – Integrated Carbon Observation System. The latter is currently being established in Norway, with strong financial support from the Norwegian Research Council, and is designed specifically to understand the carbon cycle, with emphasis on CO_2 and methane.

Continuous time series show trends

Developments over time and trends in the levels of greenhouse gases are presented in an annual monitoring report, prepared by NILU on behalf of the Norwegian Environment Agency.



Senior scientist Cathrine Lund Myhre at the Zeppelin observatory, close to Ny-Ålesund on Svalbard. Photo: Carlo Barbante, University of Venice Ca'Foscari.

– We have been taking measurements at the Zeppelin observatory since 1989, explains senior scientist Cathrine Lund Myhre at NILU's Department of Atmosphere and Climate.

– The observatory being located where it is, far from local sources of pollution, makes it uniquely suited for monitoring global levels and trends, and in particular in detecting changes in the Arctic atmosphere at an early stage. In addition, such long, continuous time series are crucial to detecting trends in concentrations of greenhouse gases and ozone-depleting substances in the atmosphere, and to see if emission mitigation measures are working as intended.

Methane set a new record in 2014

Among the greenhouse gases NILU scientists monitor are methane, the second most important anthropogenic climate driver in the atmosphere after CO_2. The measurements of methane at Zeppelin and Birkenes show that levels there increase more than the average increase globally.

– We have seen that methane levels over Norway have increased over the past eight years, explains Lund Myhre, – but in 2014 the levels of methane made a jump here in the north. The concentration in the atmosphere increased by 0.6 percent in Svalbard (12 parts per billion - ppb), and by almost 0.8 per cent (15 ppb) in southern Norway. Preliminary results of measurements in 2015 indicate a continued strong increase.

thane record in atmosphere

– There are wide variations in the methane concentrations from year to year, but in recent years we have seen a steady increase. We also see new record levels of CO_2 at both Zeppelin and Birkenes, says Lund Myhre.

Many sources of methane emission There is great uncertainty related to explaining the increase of methane in the atmosphere.

– We can't say with certainty whether the increase is due to methane emissions from human activities, or whether they may be due to climate change induced processes in nature, releasing more methane into the atmosphere, says Lund Myhre. – There may also be natural variations in eg. rainfall patterns, which gives increased emissions from wetlands, either in the Arctic or at lower latitudes.

Anthropogenic methane sources include emissions from coal, oil, gas and biomass combustion, leaks from pipelines and other oil and gas installations, emissions from ruminants, rice fields and landfills. Recently, it has been suggested that leaks from pipelines and other oil and gas installations may be an increasing source, but this needs further investigation.

Wetlands are the largest natural source of methane. Natural methane emissions constitute approximately 40 percent of the total annual methane emissions. A warmer and wetter climate may release more methane from natural sources, such as wetlands and thawing of the permafrost in taiga and tundra. Warmer seas could also lead to methane hydrates, ice-like substances in sediments under the seabed, dissolving and releasing methane to the sea, and perhaps on to the atmosphere. This is a major research topic at the moment.

Methane research at NILU

NILU has several projects where we work to understand methane sources, emissions, lures and changes. As part of the project MOCA, "**M**ethane Emissions from the Arctic **OC**ean to the **A**tmosphere," we have used oceanic measurements, ships, airborne measurements and observations from the monitoring programme at the Zeppelin Observatory to estimate the amount of methane emissions from the seabed that reaches the atmosphere in the Arctic.

A unique new collaboration is established with CAGE – Centre for Arctic gas hydrate, environment and climate at UiT. This makes such a broad measuring approach possible, and in addition CICERO contributes climate models. Thus MOCA, led by NILU, combines knowledge and methods across disciplines.

On 1 April 2016, ICOS – Integrated Carbon Observation System – *Norway* began. This is a new research infrastructure, where Norway will provide long-term observations of greenhouse gases, understanding of emissions and their regional variation. This relates in particular to measurements of carbon dioxide, methane and nitrous oxide in Norway (including Norwegian territories), the northern part of the North Atlantic and the waters around Svalbard. The measurements will be used in a model system that calculates the emissions fluxes, constrained by the observations. This will enable us to evaluate the effectiveness of various mitigations in a far better way.

The MOCA project got to take advantage of the world's best-equipped research aircraft, the FAAM research aircraft BAe 146. Here seen in the air over Prins Karls Forland on the west coast of Svalbard. Photo: CAGE

Moss and metals

Air pollution knows no borders. Particles emitted from sources far from Norway are transported through the atmosphere and deposited in Norwegian mountains and forests. Moss have proven to be especially useful when scientists want to map the atmospheric deposition of heavy metals in the environment.

Sonja Grossberndt
Scientist

Hilde Uggerud, senior scientist in NILU's Department of Environmental Chemistry, has for many years collaborated with Professor Eiliv Steinnes from the Norwegian University of science and Technology (NTNU), analysing floor moss (Hylocomium splendens; see picture). Steinnes, who first started surveying moss in Norway, has every 5 years since 1977 collected floor moss from up to 464 different locations all over the country. As of today, NILU performs the moss survey on commission from the Norwegian Environment Agency.

Natural air samplers

– Floor moss, like all moss, does not take up nutrients through roots. Nutrition is obtained through the surface of the plant and is therefore a good indicator of what is in the air and precipitation, explains Uggerud. – Moss has a special ability to bind trace elements, such as metals, radionuclides and certain organic pollutants that may accompany the rain and air. It thus acts as a kind of passive sampler. In the laboratory, we can use a variety of analytical methods to determine which substances the moss has absorbed.

The advantage of floor moss is that it grows in all parts of Norway. With more than 200 sampling sites spread throughout mainland Norway, the moss survey effectively maps the geographical deposition pattern of heavy metals from the atmosphere. This makes the moss survey a good supplement to the national monitoring of air and precipitation, which includes heavy metal samples taken from a few selected monitoring stations.

Clear trends

The moss shows several interesting trends. Deposition of metals such as lead, zinc, cadmium and vanadium is higher in the south than in the north part of the country. The reason is that southern Norway is more influenced by transboundary air pollution from Europe. In general, the data show a reduction in the contribution from long-range atmospheric deposition of these metals during the moss survey period.

This is most obvious for lead, for which the concentration in moss has dropped significantly after the phasing out of leaded gasoline in the 1990s. For metals such as nickel, copper and chromium, local sources contribute more to the concentration in moss than transboundary air pollution. An example of this is found in the high north of Norway, where emissions from the Russian smelter in Nikel has caused an increase in deposition of copper and nickel in eastern parts of Finnmark.

Industrial companies contribute

Working with the moss survey, scientists have found that in some cases it is possible to identify how local point sources contribute to the regional fallout pattern. Thus, they have carried out an additional investigation since 2000, collecting

Senior scientist Hilde Uggerud analyzes moss to map heavy metals in Norwegian nature. Photo: Ingar Næss

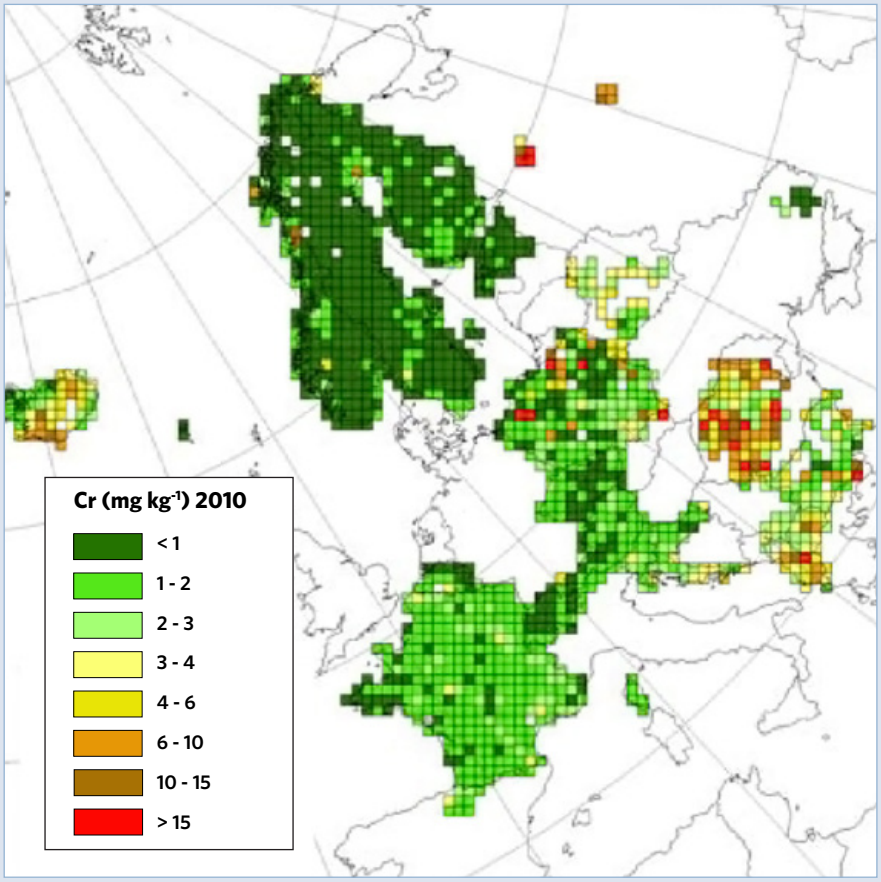
moss around various companies where they know or can assume emissions of heavy metal occur. The Norwegian Environment Agency invites companies to participate in the survey, which is funded by the companies themselves. The industry shows great interest in the survey, and 22 companies participated in 2015.
The values measured in moss from areas surrounding industrial companies are compared with values from the nation-wide moss survey. In general, the most polluted industrial estates are located in Mo i Rana and Odda. The results also indicate how well the air pollution-reducing measures work in the different companies.

A European map

– Results from the moss surveys are of international importance, says Uggerud. All data are reported centrally to ICP Vegetation, an international monitoring program under the United Nations Economic Commission for Europe (UNECE). The partnership started in 1990, with more than 20 countries participating. The common moss survey helps map the pollution situation across Europe. So far, the moss results have confirmed the results from the air measurements. The surveys show a reduction of heavy metal concentrations in moss since 1990. Lead concentrations have decreased the most, while the concentration of copper shows the lowest decline. The lowest concentrations of heavy metals in moss are found in Northern Europe, low to moderate amounts in Western and Central Europe, while the highest concentrations are reported from Southern and Eastern Europe. The results are used internationally, for example, in modeling contamination.

In 2015, yet another survey was completed. Now, the scientists are working on analysing and interpreting the data. The results will be made public in a report to the Norwegian Environment Agency and participating companies in summer 2016.

Only the top three "floors" are examined for a variety of metals: vanadium, chromium, iron, nickel, copper, zinc, arsenic, cadmium, mercury, lead and silver. Foto: Sigmund Lie.



Mean chromium concentration in mosses per EMEP grid cell in 2010 (left) and expressed as percentage of the values in 2005 (right); values below 100% represent a decline, values above 100% represent an increase since 2005. Source: Harmens et.al., *Heavy metals and nitrogen in mosses: spatial patterns in 2010/2011 and long-term temporal trends in Europe*.

Monitoring the air all over Norway

NILU owns and operates a wide range of 'background' stations around Norway. Situated slightly off the beaten track, these stations measure atmospheric composition and deposition, contaminants, climate forcers, the ozone layer and UV radiation.

Christine F. Solbakken
Head of Communications

From Birkenes in the south, to Karpdalen in the north, you will find NILU's monitoring stations for airborne contaminants. Some of them look like little log cabins, others are a simple plastic bucket in a rack. All are part of the network for monitoring air pollution in Norway.

Air pollution carried by wind and weather

– Just where these background stations are placed was determined long ago, says senior scientist Wenche Aas from NILU's Department of Atmosphere and Climate. – The aim was to get a good overview of the various types of pollutants found in the air above Norway, especially regarding what is carried here by the wind – so-called long-range air pollution. Thus, the stations are located in a way to minimise the impact of local emission sources.

The monitoring of sulphur content in air and precipitation began in 1972, as part of an extensive research project to study the effect of acid rain on forests and fisheries (the SNSF project). The project was later incorporated into the Norwegian Environment Agency's national monitoring program, as well as in the European program EMEP (*see fact box*) and several other international networks.

In the beginning, the focus was on studying acid rain mainly received from emissions in Europe. The monitoring program gradually expanded to include other environmental topics, such as eutrophication, ground-level ozone, particulate matter, environmental contaminants and climate.

Station managers for generations

Engineers Dorothea Schulze and Andreas Fiskum both work in NILU's Department of Monitoring and Instrumentation Technology. The department is responsible for maintaining the measuring instruments NILU uses for monitoring, and as part of the job, the engineers make regular maintenance visits to the various stations.

– The station managers are responsible for the daily operation, explains Dorothea. – They are locals, often farmers, and they collect air and precipitation samples from "their" background stations every day, all year round. The samples are sent to NILU at Kjeller for analysis and registration.

– Without the station managers, we could not have had such a thorough monitoring program, says Andreas. – They take great pride in performing the job properly, and several of the station manager jobs have actually been passed down for generations.

Data through time and space

Scientists use data from the measuring stations to monitor how various pollutants are spreading through the atmosphere. These basic data are used to calculate exceedances of certain limits, e.g. acidification and eutrophication.

Emissions in Europe are still the main cause of acid rain in Norway. 90% of the sulphur deposited here is carried here from other countries. Nitrogen is to a greater degree derived from national emissions, including agriculture, but more than 70% of the nitrogen is transboundary.

– Data from the background stations gives us an overview of the country, and is used to monitor a wide variety of components, Aas explains. – They are useful both to identify new environmental challenges, and to see several components in different contexts, such as particles' impact on health and climate. In addition, having continuous data from far back in time is extremely important to be able to follow the trends and the development of air pollution. We have much to thank our generations of station managers for.

Monitoring equipment at Kårvatn.

EMEP – a pan-European monitoring programme

The total monitoring of chemical compounds in air and precipitation in Norway comprises of 19 monitoring stations. 15 of the stations also measure the main components in precipitation. Five stations, among them the Zeppelin station on Svalbard, are included in the EMEP programme (European Monitoring and Evaluation Programme) under the UN Convention on transboundary air pollution (the CLRTAP Convention).

EMEP is a monitoring cooperation that has been running since the early 70s. This extensive data set provides a unique opportunity to see the historical changes in the type and amount of contaminants, and how pollution is transported across the borders through the air.

The collaboration involves about 40 countries, and contributes to political agreements on emission reductions under the CLRTAP Convention. It was the result of extensive international cooperation, to promote the understanding of how pollution can spread across borders and lead to negative effects in other countries.

NILU coordinates the chemical measurements in the EMEP programme, in addition to developing the measurement strategy, recommending methodologies, and providing training and support to member states. NILU further quality assure, validate as well as store the data from all the EMEP sites (www.emep.int).

What earthworms can tell us about ski wax

The earthworms in Oslomarka, the forested and hilly areas surrounding Oslo, are full of organic fluorine compounds that are present in ski wax. NILU scientists aim to find out the reason for this.

Sonja Grossberndt
Scientist

Early one Monday morning in February, a small group of scientists from NILU in Tromsø meet at Storelva ski stadium. The day before, the 2016 Norwegian Ski Championship ended, and now the scientists must hasten to the ski tracks. Not to go skiing – but to take snow samples from the tracks and air samples from the ski-waxing booth.

– It was actually earthworms from Holmenkollen who put us on this track, says Dorte Herzke, senior scientist at NILU.

Per- and polyfluorinated substances

Per- and polyfluorinated substances are synthetic organic substances with a high fluorine content, which breaks down very slowly in the environment. The substance group is often referred to as PFAS, with PFOA and PFOS as main compounds. PFAS are very stable substances, and when they accumulate in humans and animals they may cause DNA changes, that at worst can lead to cancer.

Although these substances are very resistant and harmful to health and the environment, they are still used in many areas, such as in paints and varnishes, in coatings of pots and pans, in impregnating agents for textiles and leather, as well as in ski wax, wax paper and fire extinguishing agents. This is due to their unique water- and grease proof properties.

PFOS is strictly regulated in most types of products. In 2007, PFOS was prohibited in fire-fighting foam. In addition, it was introduced a national ban on using PFOA in textiles and other consumer products sold in Norway. Businesses will have the opportunity to sell goods that as per 1 June 2014 was in stores. This transitional arrangement will last until 1 January 2018. The Environment Agency is cooperating with German authorities about a proposal for PFOA usage restrictions in all of EU/EEA.

Urban environmental contaminants

On behalf of the Norwegian Environment Agency (the monitoring programme "Environmental pollutants in the terrestrial and urban environment"), NILU, NINA (Norwegian Institute for Nature Research) and IFE (Institute for Energy Technology) in 2015 examined whether selected contaminants are found in plants and animals in parks, by roadsides, and near cities.

Their aim was to show how pollutants found in cities accumulate in the food chain. For this purpose, samples of earthworms, fieldfares, sparrow hawks and red foxes were analysed. The results confirm the scientists' theory, namely that animals further up the food chain shows higher concentrations of pollutants than the organisms further down the chain. They could also determine that animals in the city are exposed to a wide variety of toxic substances.

Exciting discovery

– One of the results was quite exciting, namely that earthworms from areas around Holmenkollen and Voksenåsen in Oslo showed extremely high levels of PFAS, Herzke explains. PFAS is a group of substances containing fluoride, and they are very harmful to the health of humans and animals (*see fact box*).

These substances are used in so many products and are very stable once leached into nature, that there is hardly a place on the globe where PFAS cannot be found. The problem with these chemicals is that they do not decompose, and can thus be absorbed by organisms.

Earthworms found around Voksenkollen in Oslo contain more than eight times as much PFAS as earthworms from areas where fewer people go skiing in winter. Photo: NILU

Senior scientist Dorte Herzke examines earthworms for environmental pollutions from ski waxes. Photo: NILU

Why do Oslo-worms contain so much PFAS?

– This applies primarily to earthworms from Voksenkollen, explains Herzke. The scientists' theory is that during winter, Voksenkollen is one of Oslo's busiest ski areas. Ski wax contains an excessive amount of organic fluorine compounds, which are left in the snow. After the snow has melted, the substances end up in the soil, which is the earthworm domain. Thus, the Voksenkollen earthworms contain up to eight times more PFAS than earthworms that live further away from the area.

– It is important to understand how these fluorine compounds are taken up from the soil and transferred to organisms and food chains that humans are part of, Herzke says. – So to support our theory, that PFAS in earthworms originates from ski wax, we collected snow samples from the stadium where the Norwegian Ski Championship took place in Tromsø in January this year. In addition, we took samples of air in the ski-waxing booth during the Championship, to determine how much of the hazardous fluorine compounds were emitted during the waxing process. I'm very curious about the results, which we hope are ready in the spring of 2016.

Storvatnet: Sewage, chemicals, and a source of knowledge

What happens in the bathroom certainly does not stay in the bathroom. A lot is flushed into lakes and oceans – where scientists stand ready to examine the chemicals that are carried along.

Christine F. Solbakken
Head of Communications

Storvatnet is a small lake located close to the town of Hammerfest. Sewage from surrounding residential areas was be discharged into the lake, until the sewage outlet was moved to the harbour in the 1970s. However, due to an aging wastewater system and leaking pipes, some of the sewage still ends up in Storvatnet.

What happens to siloxanes in Arctic lakes?

Storvatnet's contaminated history is by no means unique, but is one of the reasons why scientists at NILU, Akvaplan-niva and University of Leicester (UK) selected it as the study site for a project.

NORDIC-LACS (***Nordic La****ke exposure to* ***C****yclic* ***S****iloxanes: Assessment of transport, distribution and fate*), is funded by the Research Council of Norway's Miljø2015 program. Its main objective is to investigate how siloxanes – a group of chemicals widely used in personal care products such as soaps, deodorants and skin lotions – behave in Arctic aquatic environments.

From snow and ice to summer

– There is considerable uncertainty about the behaviour of siloxanes in the environment, explains Ingjerd Sunde Krogseth, a postdoctoral fellow at NILU, – but they have been found in fish and sediments in fjords and lakes affected by sewage discharge, even on Svalbard. Siloxanes' environmental fate can be influenced by Arctic conditions such as low temperatures, snow and ice. Thus, we wanted to look at how these factors affect how siloxanes actually behave in the environment and accumulate in organisms. In addition, we wanted to develop new and more robust analytical methods, and use the measurements in combination with models to perform an overall assessment of both our models and of the siloxanes. Nicholas Warner, project manager and senior scientist at NILU, says they collected samples in March and June 2014. The samples included sediments, water and sewage, as well as muscle and liver from Arctic char and Brown trout. In addition, they collected some prey of the fish; sticklebacks, mosquito larvae and tiny clams that live in the lake.

Sewage treatment and "science in the wild"

Scientists are often associated with white lab coats and clean surroundings. However, such is not always the case, as sample collection and coordination within the field can be equally important to answer questions about siloxanes fate in Arctic environments. To assess how much siloxanes emitted from Hammerfest, the local authorities helped the scientists to sample the sewage itself.

– When working with sewage samples, we need to have certain vaccines in place to reduce the risk, says Krogseth. – But it was actually worse to sample sediments from the harbour than to collect the sewage. We struggled to get good sediment samples from the harbour, where the main sewage outlet is located. As we were collecting the sediments, toilet paper, diapers, socks and other debris floating around near the bottom got in our way. The sediments we finally got didn't smell all that good, if you get my drift.

Storvatnet is located just outside the city of Hammerfest. Levels of siloxanes in the lake are comparable with those NILU scientists previously found close to Oslo and Tromsø. Photo: Ingjerd S. Krogseth, NILU

There are approximately 10,000 inhabitants in Hammerfest, and as in many small Norwegian coastal communities, the sewage is directly discharged into the sea without any treatment.

– In sparsely populated areas along the Norwegian coast, we have no tradition of sophisticated treatment plants, adds Warner. – Instead, we have lived according to the principle "the solution to pollution is dilution", and released everything directly into the sea.

Major Norwegian cities, and the Eastern coastal region down to Lindesnes, have advanced treatment that removes most of the organic matter and nutrients before the rest of the sewage is discharged to the sea. Smaller towns along the rest of the coast, however, often have only simple filtration of the sewage – or nothing. This still also applies to Hammerfest, but the municipality is working on getting a better system in place.

Closed environment provides high levels

The scientists found siloxanes in Storvatn – but not primarily in the water. Most were found in the sediments and in the fish. The levels were comparable with previous measurements near Tromsø and Oslo, which are of course much larger cities than Hammerfest.

– We think this has to do with Storvatnet being a lake, a more closed environment compared to Tromsø strait and the Oslo fjord, explains Krogseth. – Storvatnet is much smaller than these fjords, and is covered by ice in winter. Thus, the siloxanes are both less diluted, and also prevented from evaporating from the lake in winter. This allows the siloxane concentrations in the sediments to become as high as those we measured outside Tromsø in 2014 and Oslo in 2007, despite Storvatnet receiving lower emissions of siloxanes.

The researchers found high levels of siloxanes in fish, particularly in char. Summer in Hammerfest is short, and plankton is only available in Storvatnet during a very limited period. Therefore, the fish present within the lake primarily feed on benthic animals – mosquito larvae being a favourite. As benthos live down in the contaminated sediments, thus exposed to siloxanes, this may help explain why the fish in Storvatnet contain such high concentrations of these chemicals.

Siloxanes are different

Comparing measured results with model predictions, the scientists now evaluate how it all fits together. To do this, they must take into account aspects such as water flows, temperature and ice cover, and new emissions from sewers that particularly overflows during the snowmelt period in spring.

– Sewage is no longer intentionally released into Storvatnet, says Warner. – But our models show that the sewage which does enter the lake when the sewage system is overloaded can be enough to maintain the concentrations we see. Siloxanes are stored in the sediments – and it can take a long time before they disappear from there.

– This is actually quite interesting, Krogseth continues. – We often think that contaminants are more persistent in Arctic environments, because of the cold that slows down most processes. Thus, chemicals disappear more slowly there than they do further south where it is warmer. However, siloxanes can actually behave opposite to what we initially thought, she continues. – Although they degrade slower, they also partition more from sediments to the water phase when it gets cold, and thus, may be flushed out faster via water currents from Storvatnet than they would in warmer areas. However, this is dependent on the specific lake, and it shows how important specific environmental characteristics can affect the chemicals that are out there.

Storvatn of future interest

The NORDIC-LACS project ends in 2016. Nevertheless, Storvatn can still help scientists understand more about siloxanes in the environment. Many of the leaking sewers around Storvatnet were in fact repaired in 2014. This means that scientists may be able to monitor how long it takes before the concentrations of siloxanes in Storvatnet decrease as the sewage leakages (and with it siloxanes) has stopped. This is particularly interesting because of a current regulatory process at the European level, aiming to decide whether some siloxanes used in soaps and shampoos should be regulated or not. The longevity (persistence) of siloxanes in sediments is an important aspect of this process.

– It is still uncertain whether siloxanes pose a risk for fish and other organisms or not. However, finding so much of them in so many places is worrisome. It will be very exciting to see what the final outcome of the regulatory process in ECHA (the European Chemicals Agency) will be, concludes Warner and Krogseth.

Right: Ingjerd S. Krogseth during sampling at Storvatnet in March 2014.
Photo: Guttorm Christensen, Akvaplan-niva

What are siloxanes?

Siloxanes are used in various industrial applications, as fuel additives, and in a range of consumer products such as car wax, cleaning products, foam suppressants, and in personal care products. The use of siloxanes is extensive and consumption may increase in the future. Emissions to the environment occur primarily through the use of personal care products.

Siloxanes are found in several varieties, including D4 (octamethylcyclotetrasiloxane), D5 (decamethylcyclopentasiloxane) and D6 (dodecamethylcyclohexasiloxane).

Research shows that some siloxanes may be of environmental concern as they break down slowly and accumulate in living organisms. They sorb to organic matter such as that present in sediments or lipids. In the atmosphere, they can undergo long-range transport via air currents.

The siloxanes D4 and D5 are on the Norwegian Environment Agency's priority list of substances that pose a serious threat to health and environment. The aim is to stop emissions of these substances by 2020. In addition, in 2015 the UK proposed to prohibit D4 and D5 in levels higher than 0.1 % in personal care products that are washed off during normal use, such as shampoo, conditioner and soap. In March 2016, the proposal was agreed on by the ECHA's Committee for Risk Assessment. A final decision is expected later this year.

In 2013, 62 % of the Norwegian population were connected to high-grade wastewater treatment plants (chemical and/or biological treatment), while the rest are connected to mechanical filtration or no treatment. The high-grade purification exists primarily for discharges to fresh water and to the North Sea between the Swedish border and Lindesnes. Sewage treatment is mainly designed to remove organic matter and nutrients, and not environmental contaminants.

Soil Moisture: Water as key

Water held in the soil is crucial for plant growth and has close links to weather and climate. This is because soil moisture is a key variable in the exchange of water and energy between land and atmosphere.

William Lahoz
Senior Scientist

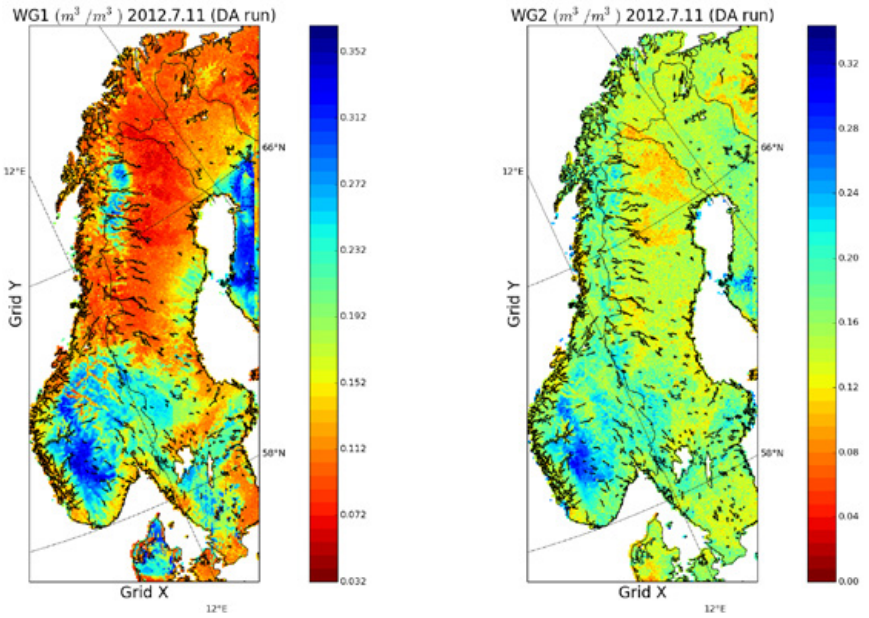
A novel development at NILU during the last few years is a core set of research activities to study the land surface, with focus on soil moisture. Soil moisture is a key variable of the hydrological cycle, playing a vital role in the Earth Climate System.

State of the land surface

The study of the hydrological cycle is important over the Arctic, as we expect this region to be especially sensitive to Climate Change in the 21st Century. Furthermore, the hydrological cycle is difficult to monitor in this region. These facts provide a strong motivation for the soil moisture work at NILU.

In the past few years, NILU has established itself as a key player within the Nordic Areas, developing a strong collaboration with the Norwegian and Swedish Meteorological Offices; this complements the original collaboration between NILU and Météo-France, who provided NILU with the state-of-the-art land surface model it uses for its studies. As an example of NILU's work, a recent paper provides the first study evaluating soil moisture observations from satellite platforms over Norway.

The work at NILU makes use of sophisticated modelling tools and algorithms to combine satellite observations and model simulations of the land surface to obtain an objective estimate of the state of the land surface, including soil moisture. First results indicate that estimates of the state of the land surface provide useful information to monitor its temporal variability, especially over the Nordic areas, and extend our knowledge of the elements influencing the exchange in water and energy between the land and the atmosphere. We expect to provide estimates of the land surface at unprecedented high spatial and temporal resolution.



Estimates of superficial soil moisture (left panel) and volumetric soil moisture (right panel) for 11 July 2011 over the Nordic areas, units of m^3m^{-3}. Blue/red colours indicate relatively high/low values of soil moisture. We derive these estimates by using a mathematically based algorithm (called data assimilation) to combine in an objective way observational and model information and their errors. The observational information is soil moisture data from the SMOS (*Soil Moisture Ocean Salinity*) ESA satellite; the model information is output from the SURFEX land surface model.

Future work

There are many future lines of research regarding soil moisture at NILU. One is the production of high-quality multi-year estimates of soil moisture over the Nordic Areas, to monitor and study the Arctic hydrological cycle and its response to climate change in the 21st Century (*Fig.*). A second focuses on the prediction of extreme weather events in Norway, such as floods and droughts.

It is also important to develop a methodology to couple the atmosphere and land surface elements of the Earth System, and provide better forecasts of atmosphere and land surface variables. A third line of research at NILU will develop such a coupled system. The benefits from this methodology will come from a better representation of the exchange of information between the atmosphere and the land surface. Finally, besides soil moisture, there are plans to monitor and simulate snow observations over Norway, and study the connections between vegetation and the land surface. There is every reason to expect that the land surface work at NILU will continue to develop and provide insight into the Arctic hydrological cycle, with benefit to various stakeholders, including academia, the weather centres, public bodies, industry (e.g., tourism, energy), and policy makers.

Partners and funding

Various funding sources support this work, including the ESA CCI for soil moisture (http://www.esa-soilmoisture-cci.org/; of which NILU is a partner); the Norwegian Research Council; and the Norwegian Space Centre.

Climate change rapidly warms world's lakes

In December 2015, a sensational study was published showing that lakes all over the world are warming by an average of 0.34 degrees Celcius each decade. Lakes in Northern Europe can be affected with an average warming of 0.72 degrees Celcius within the same period.

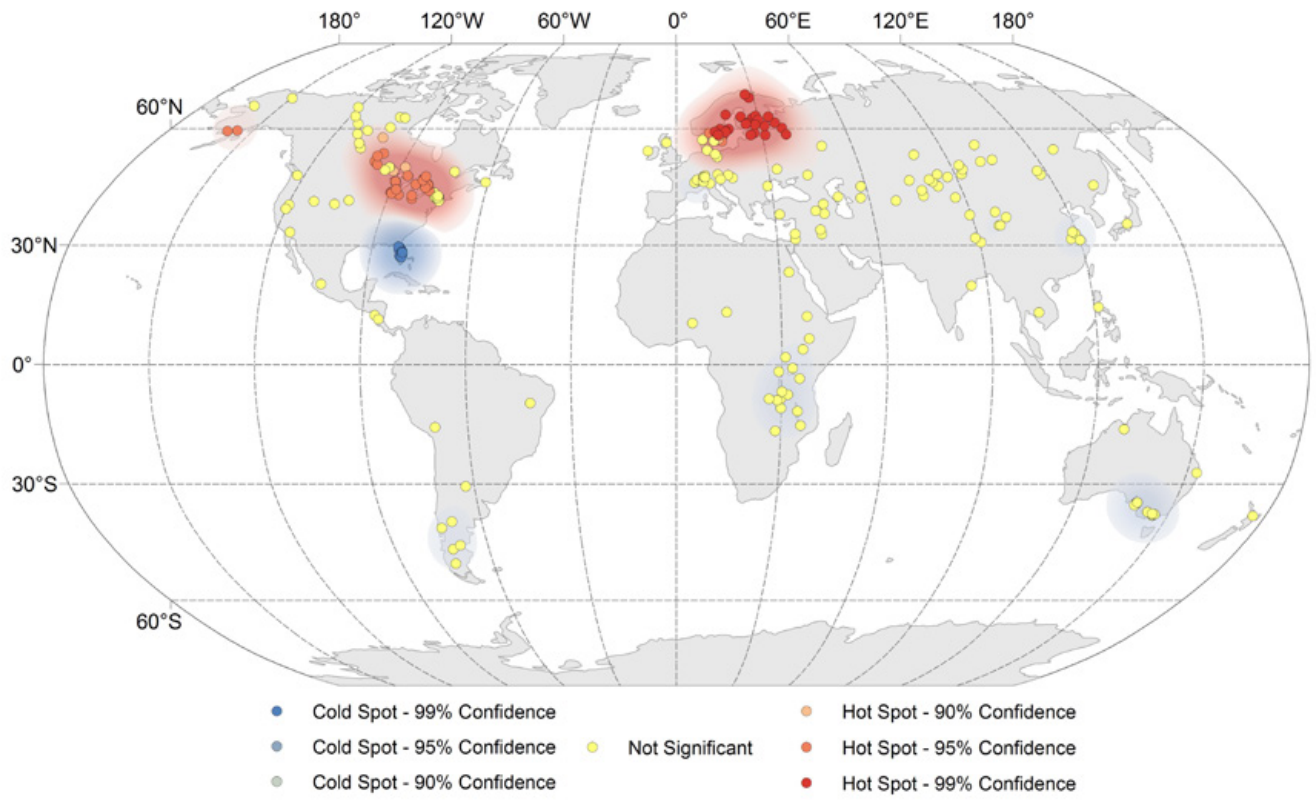
Christine F. Solbakken
Head of Communications

This warming is greater than the warming rate of either the oceans or the atmosphere, and according to scientists, it can have profound effects. The change in temperature is a severe threat to freshwater supplies, ecosystems and fish, and in the worst case, can even lead to the extinction of species.

– This research is groundbreaking, says Philipp Schneider, senior scientist at NILU and lead of the satellite data analysis for the study. – For the first time a study combines global satellite data on lake surface temperature with the world's largest collection of ground-based measurements of lake temperatures compiled so far. These two datasets complement each other and allow us to better detect patterns of change of global lake temperatures in both time and space. In addition, we improve our understanding of the underlying mechanisms.

Satellite measurements provide a broad view of lake temperatures over the entire globe, but they only measure surface temperature. Hand measurements, however, can detect changes in temperature throughout a lake. Also, satellite measurements go back only 30 years while some lake measurements go back more than a century.

Funded in part by NASA and the National Science Foundation, the study is the largest of its kind and contains data from 235 lakes that have been monitored for at least 25 years. While that is a fraction of the world's lakes, they contain more than half the world's freshwater supply.



Revolutionizing car technology through smart sensing

Although European air quality has improved considerably during the last decades, it is still estimated that more than 1,500 deaths each year in Norway can be connected to bad air quality. Most people know they can be affected by bad air quality when outside or close to traffic. But did you know that you can also be exposed to pollutants inside your car through the ventilation system? This relatively new research area is now addressed through the ECLECTIC project, opening NILU's way into new markets.

Sonja Grossberndt
Scientist

ECLECTIC stands for "Enabling Clean Air Environment in Cars and Smart City Services through Big Data Processing" and its main goal is to reduce the exposure to air pollution for drivers and passengers inside their cars. Equally important, ECLECTIC will also reduce the emissions from cars at places where the concentrations are high or in "green zones," where good air quality is anticipated, like close to schools and kindergartens. With the preparatory work already begun in 2015, NILU is responsible for all developments of the project.

Smart cars

– We will develop a new technology called "smart air inlet", explains Morgan Kjølerbakken, scientist at NILU and responsible for the technology development. – Outdoor air quality data obtained from all cars equipped with this technology is going to be combined with data from local air quality measurements, traffic flow and air quality modelling based maps. The new technology will cause the car to adjust the air inside the cabin automatically: incoming air can thus be reduced when the air quality is bad, and increased when the air quality is good. The data will also be used in our so called "clean air route planner." This tool will help car drivers to plan their trips by choosing routes that are less polluted.

Green zone adapter

– But we can do even more with our technology, continues Kjølerbakken. – The real-time air quality information will also be used to adapt the driving mechanism of the car to its environment. For example, if a hybrid car is passing a school, the ECLECTIC technology will make the car switch into electric mode automatically. Or if a fuel driven vehicle is driving along a park, the new technology can cause a switch to "eco mode." This will dramatically reduce air pollution and help create a cleaner environment.

ECLECTIC aims to be the service provider for all car manufacturers, but wishes to approach new technology players in the field – such as Google and Apple – in the not too distant future. This is a project with large corporate/innovation potential, where there is currently little or no competition.

Research and innovation

– This project is not only an exciting exercise, but will also give us great opportunities to improve nowadays technologies, remarks Kjølerbakken enthusiastically. – We will have entirely new opportunities on the market, and get to apply NILU's research in innovative ways. I am very much looking forward to this project!

ECLECTIC is coordinated by Kjeller Innovation with NILU and the Norwegian Public Road Administration (Statens vegvesen) as partners. The project obtains funding from the Research Council of Norway through the FORNY2020 program.

WAG: Everything between heaven and earth

WAG AS is a joint venture owned by NILU and three other Norwegian research institutes: the Norwegian Institute for Water Research (NIVA), the Norwegian Geotechnical Institute (NGI) and the Institute for Energy Technology (IFE).

The idea for WAG arose when three Americans, James Strout of NGI, James Berg from NIVA and John Ackerman from NILU, met and discovered that they could join forces to bring new technology to the table. They decided to establish a new corporation, a so-called SME (small and medium enterprises), with the additional bonus that the company can compete for EU project funding.

– The objective was to develop and commercialize research results within each institute's main expertise area: that of water, air and geotechnology (Water, Air, Geotechnology), explains Pål Midtlien Danielsen, head of NILU Innovation. Later, the Institute for Energy Technology (IFE) was invited into the community.

The owner institutes have developed passive samplers for different types of contaminants, now distributed by WAG. Moreover, the company have received approval on its first major government-funded project, a platform for the development and commercialization of new products and services. WAG is allocated funding for this project by the regional innovation program in Akershus County.

– WAG has evolved to become a very exciting player with a rare combination of disciplines, says Danielsen. – An important additional point is that those involved in company activities get good opportunity to discuss ideas and share experiences with each other across institute boundaries within different areas (innovation, commercialization, project development and financing, etc.). We will surely see other WAG projects and initiatives for cooperation in the future.

In search of Bedrock

The idea for the FORNY2020 funded project, Bedrock, arose in the mind of NILU engineer Rolf Haugen, and has since developed in partnership with Kjeller Innovation and NORSAR.

– There are many expensive ways to find the distance from the ground surface level to bedrock, says senior scientist Leif Marsteen, who is also involved in developing the Bedrock project.

– Our goal is to offer a cheaper and easier method to both the professional and private market.

The Bedrock technology is very versatile, and applicable in everything from road planning and railways to construction and drilling. The first test rounds gave positive results, but also exposed challenges – such as uncovering what kind of soil conditions lie between the surface and the bedrock.

This is what the team, consisting of Marsteen and Haugen from NILU, Jan Fredrik O. Häger from Kjeller Innovation and Volker Oye, Dominik Lang and Abdelghani Meslem from NORSAR, aims to discover during the next round of tests. If the tests are satisfactory, they will be repeated in a larger and more real scale, in cooperation with heavy industry players.

– It will be interesting, says Marsteen, – and we look forward to continuing.

Engineer Rolf Haugen is the mastermind behind the Bedrock Technology. Photo: Ingar Næss

Strengthening the air quality assessment system in Poland

Advising policy makers on air quality management is an important activity at NILU. In 2015, NILU and the Chief Inspectorate of Environmental Protection (GIOŚ) in Poland carried out a project on "Strengthening the air quality assessment system in Poland," based on Norwegian experience.

Jozef M. Pacyna
Research Director

As part of the programme "Improving Environmental Monitoring and Inspection" within the European Economic Area (EEA) framework for Financial Mechanism 2009-2014, the project provided an important opportunity for NILU to help improve air quality management outside Norway.

Improving air quality data

The general aim was to strengthen the capacity of GIOŚ to provide timely and reliable data on air quality in Poland. The project should also provide a proper air quality information system, reporting air quality data nationally and internationally in accordance with the new requirements.

Overall project goals were:

- To improve the Polish air quality (AQ) emission inventory and modelling capacity
- To improve the monitoring system providing on-line information on AQ in Poland
- To stablish an internet service visualizing air quality data of GIOŚ

Polish monitoring station operated by WIOS Rzeszow. Photo: Marzena Załęska

The project also aimed to optimise and modernise the AQ monitoring network in Poland, including IT tools and software solutions, and service and maintenance of monitoring stations.

Providing for the future

The existing ambient air quality monitoring networks in Poland were first analysed in line with the EU Directive requirements. The analysis was based on information from the existing measuring equipment used in the Polish Voivodeship networks, and supplementary information.

Based on this analysis, NILU scientists reviewed the plans for purchasing new equipment, i.e. the future monitoring equipment acquisitions proposed by GIOŚ (funded by the EEA Financial Mechanism through another project carried out by NILU in Poland). The scientists also made specific recommendations on how to improve the networks in order to meet the EU Directive requirements regarding data coverage, and gave advice on implementation of various norms and standards.

During the project, guidelines for combining measurements, modelling tools for estimating concentrations in areas not covered by the monitoring networks, and modelling tools for source contribution in highly polluted areas were also provided.

Particulate matter and modeling

Among several other activities, NILU also contributed to improving the QA/QC procedures in Poland, by means of e.g. inter-calibrations/common field campaigns. The main goals were to review and improve how to determine which areas were characterised by high concentrations of particulate matter (PM_{10} and $PM_{2.5}$, and their chemical composi-

Monitoring station in Mielec, Poland, operated by WIOS Rzeszow. Photo: Marzena Załęska

tion), and to participate in a suspended particulate sampling inter-comparison in Zabrze in Poland.

NILU also supported Polish authorities in their work on adapting the air quality assessment to the new EU requirements, particularly including spatial data and modeling. This was especially related to:

- Developing the initial concepts of implementing a support system for air quality assessment, based on Norwegian experiences
- Preparing terms of reference for a pilot air quality assessment, using the selected model (or models)
- After completing the pilot modeling study, preparing recommendations for an air quality assessment by a Polish modeling center

Using modeling data

The EU Air Quality Directive (2008/50/EC) opens for a broader use of air quality modeling techniques than previous EU air quality legislation. It states that "where possible, modeling techniques should be applied to enable point data to be interpreted in terms of geographical distribution of concentration. This could serve as a basis for calculating the collective exposure of the population living in the area".

In Poland, air quality models have been used under different programs to assess air quality levels at different scales, and provide timely forecasts of some specific pollution compounds. However, the use of these air quality models was not harmonized in a consistent framework, to support reporting to the Air Quality Directive.

To improve this, a pilot study was thus launched, where NILU proposed experience-based terms of reference, aiming to facilitate the development of a consistent and harmonized model for use by all affected national environmental entities in Poland. The NILU scientists gave both short-term and long-term recommendations, with regard to application of emission and meteorological data in the models, use of various models, and the spatial analysis of model results and data fusion issue.

Providing understanding

NILU's final project task in Poland was to provide GIOŚ with a portal for visualization of air quality monitoring data, as a part of spatial information system compliant with INSPIRE requirements. This was to support GIOŚ in their work on developing a comprehensive air quality visualization and dissemination web portal for the whole of Poland.

Guidelines were proposed on how to best reach a defined target audience, and methods were proposed to ensure that those most affected understand the air quality information.

This successful project proves that NILU's knowledge about air quality management on urban, regional and national scales is both very useful and applicable also in other countries.

Awards and honors in 2015

Jozef M. Pacyna admitted as a new member of the European Academy of Sciences and Arts

February 2015: Jozef Pacyna, Director of Research at NILU, was admitted as a member of the European Academy of Sciences and Arts.

The Academy of Sciences and Arts is a European professional forum with 1,500 members. The academy focuses on European issues, and the 1,500 members are divided into 7 classes: humanities, medicine, art, natural sciences, social sciences/law/economics, technology/environmental science and world religions.

A committee elected by the Senate nominates new members, and all nominations are based on academic merit. Being inducted as a member of the academy is a distinction and recognition of scientific work.

Jozef Pacyna states that "membership in the academy will give me the opportunity to contribute to a better understanding of major political, social and environmental problems, and issues facing Europe today. Together with scientists from other countries, I get to work to find solutions to these challenges and help build bridges between different scientific disciplines, as well as political and religious systems in Europe today."

ERC Advanced Grant awarded Dr. Andreas Stohl

June 2015: Senior Scientist Dr. Andreas Stohl was awarded an ERC Advanced Grant, the most prestigious research funding award given by the European Research Council (ERC), for the project COMTESSA – Camera Observation and Modelling of 4D Tracer Dispersion in the Atmosphere.

Turbulence is one of the long-standing big challenges in the atmospheric sciences. But, according to Stohl's ERC application, COMTESSA will push back the limits of our understanding of turbulence and plume dispersion (e.g., of pollutant plumes) in the atmosphere by bringing together fully four-dimensional observations of a nearly passive tracer (sulphur dioxide, SO2), with advanced data analysis and turbulence and dispersion modelling.

The highly interdisciplinary work performed in COMTESSA is made possible because Andreas Stohl is joined by a unique selection of scientists with complementary expertise. Besides Stohl, NILU scientists Massimo Cassiani, Kerstin Stebel, Arve Kylling, Norbert Schmidbauer, Ignacio Pisso and Jonas Gliß will take part in the project.

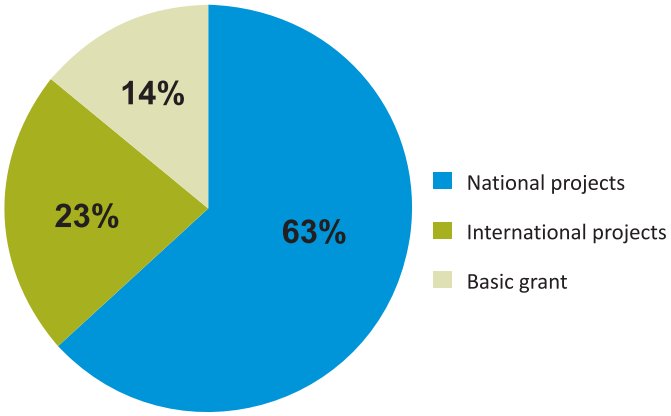
Key figures

Extract from the annual statement: All figures in MNOK

Income statement	2015	2014
Project revenue	158,9	151,3
Basic grant*	27,0	25,6
National tasks and grants	11,0	9,1
STIM-EU	1,4	0,7
Other operating income	0,7	0,8
Operating revenue	**199,0**	**187,5**
Wages and social expenses	-132,6	-137,2
External expenses	-21,7	-23,6
Other expenses	-34,4	-33,6
Operating profit	**10,3**	**-6,9**
Net financial items	9,8	1,7
Tax	-6,5	0,8
Profit for the year	**13,6**	**-4,4**

Balance sheet	31.12.15	31.12.14
Fixed assets	98,9	123,0
Current assets	98,8	76,1
Total assets	**197,7**	**199,1**
Total equity	120,5	115,9
Long-term liabilities	14,5	15,9
Short-term liabilities	62,7	67,3
Total equity and liabilities	**197,7**	**199,1**

Project portfolio – percentage 2015



Number of man-years	31.12.15	31.12.14
Total	160	164
– whereof research man-years	92	94
– whereof men-years of other personelle	68	70
Turnover per research man-year (MNOK)	**2 163**	**2 068**

Number of employees	31.12.15	31.12.14
Total	175	179
– whereof women	87	90
– whereof men	88	89
Number of employees holding a doctorate	**67**	**71**

Project protofolio – percent	2015	2014
National projects	63 %	63 %
International projects	23 %	23 %
Basic grant	14 %	14 %
Total	**100 %**	**100 %**

NILU's publications	2015	2014
Peer-review article	147	124
Scientific reports	40	69
Technical reports	0	2
EMEP/CCC reports	5	4
Lectures	124	139
Posters	45	32
NILU scientists also contributed to the publication of:		
External reports	20	15
Chapters/articles in books/reports	25	55

Number and nationality of employees

2015: 175 employees of 22 different nationalities
2014: 179 employees of 25 different nationalities

**strategic institute initiatives included*

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