NILU

Annual report 2018

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About 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, provides 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 Dept. 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 Dept. 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 Dept. of Environmental Impacts and Sustainability 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 Dept. 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 Dept. 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 Dept. is responsible for development and maintenance of NILU's software and hardware products, 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

Christine Forsetlund Solbakken, editor.
Ingunn Trones, contributions and adaptions.

Photo front page: Colourbox

MILJØMERKET 241 013 TRYKKSAK

NILU is ready for the future

The concentration of greenhouse gases in the atmosphere continues to rise. At the same time, we applaud the increasing climate commitment from the younger generation. One of NILU's most important tasks is researching into the global change of environmentally harmful substances in the atmosphere. With solid science as a basis, for the last 50 years we have contributed knowledge-based information to national authorities and international conventions.

Both greenhouse gases and some environmental pollutants are transported through the atmosphere to the entire globe. Thus, it is important to promote cooperation between the nations in order to find the best solutions - and involve both the business community and citizens.

The cooperation in the UN international conventions is important in order to ban the use and promote the phasing out of known environmental pollutants, while also trying to facilitate the development of new substances will not impair the atmosphere on the planet. To do this, it is important to quickly gain knowledge of new chemical substances, and be able to detect them early on.

Environmental pollutants are everywhere – even in the dust bunnies hiding behind your sofa. NILU has for many years worked to raise attention about what this means for the indoor environment and our health. Increased efforts in this field is sorely needed.

Plastic is a major environmental problem. Plastic does not break down - it breaks apart. Where the smallest particles end up, and what that means for the environment, is a field NILU is researching in collaboration with other strong academic institutions in Norway and internationally. Plastic pollution of the oceans has been an eye-opener for many, and serves as an "engine" for people's increased awareness of environmental pollutants in our everyday lives.

Plastic pollution is very visible, while many other harmful substances are invisible to us.

Air quality in the city is important for those who live there. We have quite a good understanding of the traditional monitoring parameters in the air in our cities, however, there are a number of potentially harmful substances in the urban air that we know little about. That is why NILU wants to build a City Observatory in Oslo. It can provide better information about these possible air quality challenges. We have extensive experience with atmospheric observatories in both the Arctic and Antarctic – these monitor the pulse of the atmosphere – and now we will use this experience to improve the understanding of urban air.

Innovation is important for all research environments, and much of what NILU does is direct or indirect innovation. We contribute to changing society in a positive way. In traditional innovation – product development – we have recently developed a prototype for testing of fluorine in ski waxes.
In this annual report, you can read about several aspects of our exciting new initiatives and about world-class research.

Enjoy your reading!

Kari Nygaard
Adm.dir

Foto: StudioF2, Fotograf Ingar Næss

Greenhouse gas levels are constantly rising

The most important greenhouse gases monitored by NILU – The Norwegian Institute for Air Research continued to rise in 2017. Levels have now reached new records both at Svalbard and in Aust-Agder in Norway. Both CO_2, methane and nitrous oxide continue to increase in both Southern Norway and Svalbard, and there is no sign of reduction or flattening in this trend.

Previously, scientists has stated that the CO_2 concentration in the atmosphere had to be below 400 ppm in order to achieve the international goal of not exceeding two degrees global warming.

"Significant reductions in both CO_2 and methane are needed to reach the goal of only two, or preferably 1.5 degrees of heating," explains senior scientist Cathrine Lund Myhre from NILU.

"The 1.5-degree target is actually so ambitious that CO_2 emissions must be down 45% compared to 2010 by 2030. Moreover, it does not stop there. We have to cope with net zero emissions of CO_2 by 2050."

In order to monitor the changes in emissions, precise observations of greenhouse gas levels in air is essential. Lund Myhre leads the national monitoring program "Monitoring of greenhouse gases, ozone layer and atmospheric pollutants". Results are published in the annual report "Monitoring of greenhouse gases and particles in Svalbard and Birkenes in 2017". The report states that the two most important greenhouse gases, CO_2 and methane, also set new records last year. This also applies globally, according to a new World Meteorological Organization (WMO) report that came today.

CO_2 is still rising over Norwegian areas and the Arctic

NILU carries out the monitoring program on behalf of the Norwegian Environment Agency. At the Zeppelin Observatory at Svalbard, they measure 46 different greenhouse gases, in addition to CO_2 and methane measurements made at the observatory at Birkenes in Aust-Agder. In 2017, the annual average concentration of CO_2 in the atmosphere was record high – 408.0 ppm (parts per million) at Zeppelin and 411.3 ppm at Birkenes. There are increases of 3.6 ppm (0.89%) and 1.5 ppm (0.37%) respectively from 2016.

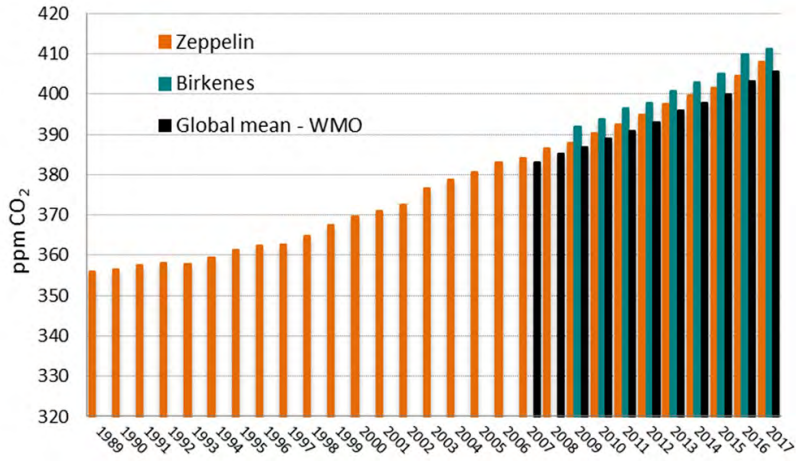


Figure 1: The orange bars show the annual average concentrations of CO_2 measured at the Zeppelin Observatory during the period 1989-2017. The green bars show annual average values from Birkenes. The latest global 2017 average published November 22, 2018 from the World Meteorological Organization (WMO) is shown in black (WMO, 2018).

"The increase of 3.6 ppm on Zeppelin from 2016 to 2017 is the second highest increase we have measured since the start in 1988," Lund Myhre says.

"When we compare with data from the WMO report, we see that the CO_2 levels have increased more than the global average increase (an increase by 2.2 ppm from 2016 to 2017). This is partly because there are more people living in the northern hemisphere, with associated higher CO_2 emissions from industry, traffic, combustion and other sources."

The methane levels in the north at a new record level

The concentrations of methane also reached new heights in 2017, with an annual mean value of 1939 ppb (parts per billion) at Zeppelin and 1945 ppb at Birkenes. Compared to the 2016 levels, this represents increases of 7 ppb (0.35%) and 3 ppb (0.18%) on Zeppelin and Birkenes respectively.

For Zeppelin, this is comparable to the global increase, which was 7 ppb for the same period. The changes over the last few decades are large in relation to the development of the methane level in the period 1998-2005, as the changes were virtually zero on both Zeppelin and globally. Understanding the reason for this is a complicated and important research topic.

As Figure 2 shows, the methane concentration in the atmosphere is much higher here in the north than the global average. About 60% of methane emissions originate from manmade sources. The major difference between levels here in the north and global values, is that most methane emissions occur in the northern hemisphere. In addition, it takes some time before the methane mixes with the global atmosphere.

Natural methane sources include wetland areas, termites and ruminant gut gas. In addition, there are thawing permafrost and possible processes in the sea that lead to emissions of methane from reservoirs under the seabed. The new report from the UN Intergovernmental Panel on Climate Change on how to limit heating to 1.5 degrees, assumes that methane emissions are reduced by 35% compared to the 2010 level by 2050. To achieve this, it is crucial to know as much as possible about the methane sources and how they change over time. In particular, it is important to understand the balance between manmade sources and natural sources.

What Meta Sources Are Changing?

NILU has measured methane isotopes on Zeppelin since 2012, as part of various research projects funded by the Norwegian Research Council, but it is only now that these measurements are included in the monitoring program.

"The isotope signatures can tell us more about which sources the methane comes from," explains Lund Myhre. "Methane from fossil sources such as oil and gas installations, or combustion of biomass, for example, has a different isotope signature than methane that comes from wetlands in the Arctic or lower latitudes."

In other words, isotope signatures are very useful as additional information when researchers want to find out more about the different sources of methane in the atmosphere, and why methane increases so much. However, in order to provide answers, they must be combined with monitoring of methane level and solid models.

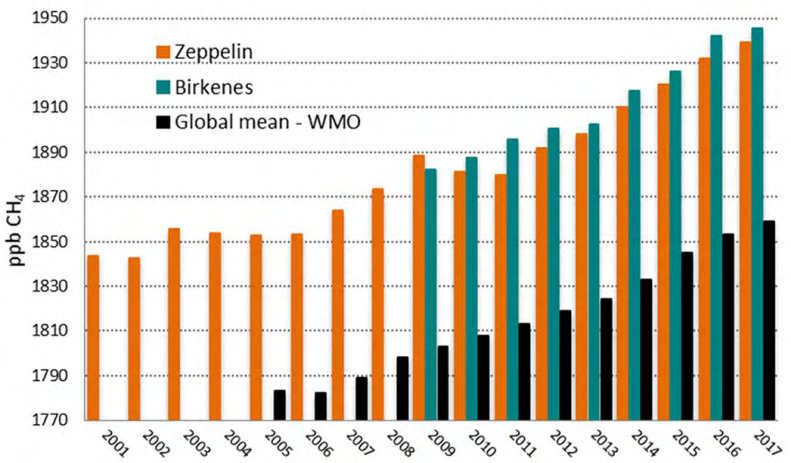


Figure 2: Development of annual average methane concentration in the atmosphere indicated in parts per billion (ppb). The orange bars show annual mean values measured at the Zeppelin observatory in the period 2001-2017, the green bars correspondingly measured at the Birkenes observatory in the period 2010-2017. The black bars show the global average published November 22, 2018 from the World Meteorological Organization (WMO, 2018).

At Zeppelin, the researchers see a clear reduction (more negative values) in the methane isotope $\delta\,^{13}C_{CH4}$ after 2012, in parallel with the increase in methane levels.

This indicates that the bulk of the increase is not due to an increase in emissions from fossil sources. Instead, it is probably due to emissions from sources such as wetlands at both northern and southern latitudes, ruminants and changes in forest fires. Many of these sources are very vulnerable to climate change, such as changes in precipitation and temperature.

Monitoring is crucial for finding solutions

"The most likely answer is that it is a combination of human and natural sources that account for the increase in methane levels we have seen in recent years," Lund Myhre says.

"It can also be about changes in methane degradation in the atmosphere, so it is not easy."

By combining these unique datasets with models, scientists can in the long term provide much better and safer answers to what is happening, and thus the basis for what can be done.

The monitoring program provides a completely central database in the work of finding solutions to limit the temperature increase to 2 or preferably 1.5 degrees.

NILU measures greenhouse gases over Norway

On behalf of the Norwegian Environment Agency, NILU – Norwegian Institute for Air Research, measures greenhouse gases and ground-level ozone on two atmospheric «supersites»; The Zeppelin Observatory at Svalbard and the Birkenes Observatory in Aust-Agder, Norway.

The measurements at the Zeppelin Observatory represent developments in the Arctic and the entire northern hemisphere for the long-lived greenhouse gases, while the Birkenes Observatory is located in the area in Norway that is most affected by emissions from the continent.

The measurements are part of the national program «Monitoring of greenhouse gases, ozone layers and atmospheric pollutants», which in turn is part of the state monitoring of pollution in Norway. The 2017 report includes measurements of 46 greenhouse gases and includes the most important naturally occurring greenhouse gases, synthetic greenhouse gases and various particle properties that have high relevance to radiation and climate. Many of the gases also have a strong ozone-depleting effect.

For most greenhouse gases, development and trends for the period 2001-2017 have been reported, in addition to daily and annual average values. The program was expanded with 16 new gases in 2015, and further with six new gases in 2016. Data for the new components has been collected and analyzed back to 2010.

Sensor nodes and outdoor air quality at kindergartens

The prevalence of childhood asthma has increased over the past decades. It is now the most common chronic illness in children and the leading cause of pediatric hospitalization worldwide.

Numerous studies have indicated that exposure to traffic-related air pollution is associated with the increase in the incidence of childhood asthma or the development of asthma symptoms.

Norwegian toddlers sleep outdoors

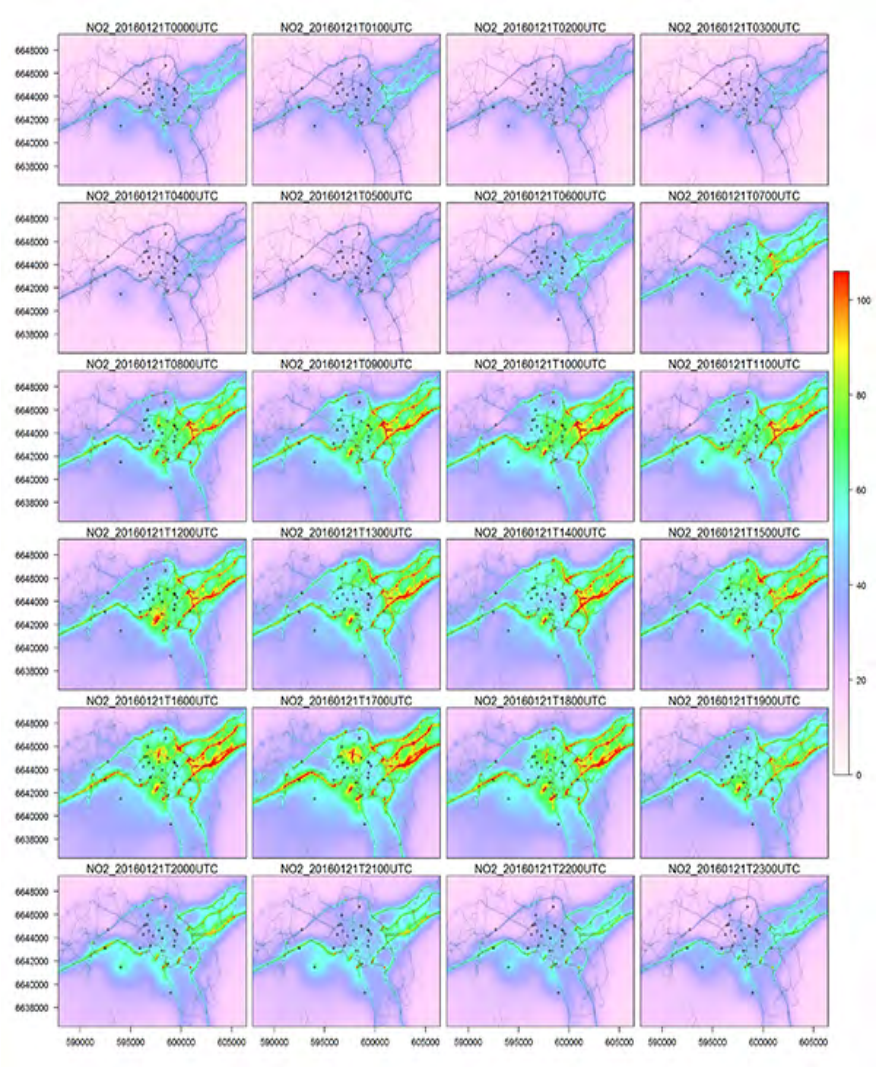
In Norway, children in kindergartens spend significant time outdoors under all weather conditions, and smaller children often sleep outdoors in their stroller. There is thus a natural concern about the quality of outdoor air. Especially during winter and spring, kindergartens in Oslo that are situated close to streets with busy traffic, or in areas where wood burning is used for house heating, can experience many days with bad air quality. During these periods, updated information on air quality levels can help the kindergarten teachers to plan appropriate outdoor activities and thus protect children's health.

During the last decade, the development of low-cost monitoring platforms has seen significant growth. Low-cost sensor nodes have a lower price than reference instrumentation and have the advantage over other traditional methods, such as diffusive samplers, that they can monitor at high temporal resolution. This enables observations at high spatial resolution in near-real-time and provides an opportunity to continuously monitor air quality at places of interest like kindergartens.

Study in Oslo kindergartens

Senior scientist Núria Castell and her colleagues installed 17 low-cost air quality nodes in kindergartens in Oslo. These nodes are smaller, cheaper and less complex to use than traditional equipment. Performance evaluation shows that while they are less accurate and suffer from higher uncertainty than reference equipment, after calibration and quality data assurance, they still can provide reliable coarse information about local pollution.

"In order to provide near-real time high-resolution spatial maps of air quality, we developed an approach



Air quality NO2 map for the city of Oslo created by merging the data from the static sensors and the annual average NO2 concentrations from an air quality model. The results are for the 21st of January 2016 from 00:00 to 23:00. The map shows NO2 concentrations in ppb. The dots represent the location of the 24 AQMesh nodes.

based on data fusion techniques", Castell explains.

This allowed for combining the low-cost sensor hourly observations (representing temporal variability) with a characterization of spatial distribution derived from an air quality model. Thus, the scientists obtained a reflecting short-term air pollution variability (see figure).

"We made use of focus groups in order to obtain feedback from local administration, kindergarten staff and parents about their need related to air quality information in kindergartens", Castell continues.

Senior scientist Núria Castell. Photo: StudioF2, Ingar Næss

The scientists were specifically interested in the focus group members' opinion on the air quality data generated in this study. Many expressed concern about the data quality, but most agreed that having updated information on the air quality in the surroundings of kindergartens can help them to reduce children's exposure to air pollution.

What now?

There is an increasing interest in receiving personalized air quality information to change kindergarten practices to protect children's health.

"The outlook for low-cost sensor nodes is promising," Castell says. "We have demonstrated the big potential that lies within this new technology to provide localized real-time air quality information, especially when combining it with data fusion techniques."

Photo: Christine Forsetlund Solbakken, NILU

NILU to lead EEA's topic center on air quality and noise problems

Air quality in Europe is getting better. However, a significant proportion of Europe's population still lives in cities and areas where at times, noise and air pollution may lead to health problems. Norwegian scientists are now tasked with leading the work of compiling the knowledge base the decision-makers in Europe need to give us better air and quality of life.

Air contamination does not care about borders. Air pollution is also closely linked to transport, noise and pollution from industry. Thus, solutions that lead to abatement in one of the fields should help to remedy the others. That is, in very short terms, the background for the European Topic Center on Air pollution, Transport, Noise and Industrial pollution – ETC/ATNI, which will assist the European Environment Agency (EEA) in the efforts to improve air quality in Europe. They will also look into transport systems, noise and industrial pollution.

The EEA has assigned the topic center to a consortium led by NILU – Norwegian Institute for Air Research. In addition, the consortium consists of organizations from Austria, Czech Republic, France, Greece, Spain and the United Kingdom. The new topic center starts in 2019.

Air pollution is a Pan-European problem

One of EU's overall objectives in its Environment Action Program to 2020 is to "safeguard the Union's citizens from environment-related pressures and risks to health and wellbeing".

The seven EEA topic centers are important measures to ensure this. Together, they will assist the EEA in all environmental areas where the EU designs policies, for example industrial pollution, climate change mitigation, climate change impacts, water management, resources and ecosystems, marine and coastal environment, biodiversity, ecosystems, agriculture and forests, in addition to air quality and urban challenges.

"It will be exciting to lead a highly interdisciplinary team who both wishes and has the opportunity to collaborate across all environmental policy areas," says NILU's EU coordinator and research director Alena Bartonova.

"The recognition that environmental challenges must be solved based on the knowledge of the environmental system as a whole is central to our work."

Bartonova and research director Cristina Guerreiro will lead ETC/ATNI on behalf of NILU. Bartonova believes that the topic center's work will provide a better understanding of challenges the different countries face when they implement policies and measures to improve the environment.

"The challenges can be anything from technical problems with digitalization and data acquisition, integrated assessments and generating the knowledge base, right up to governance challenges," she says.

"To establish a well-functioning system for environmental protection, we need to connect all of these elements."

In addition, Guerreiro believes that although good solutions to address certain challenges exists, there is an increasing need to see environmental problems in context.

"It is necessary to take into account all relevant considerations," she says, "everything from air quality, climate change and noise to the design,

Alena Bartonova is the designated ETC/ATNI manager at NILU. Photo: StudioF2, Ingar Næss

Cristina Guerreiro will be the deputy head of ETC/ATNI and lead NILU's professional work for the EEA Photo: StudioF2, Ingar Næss

implementation and evaluation of environmental policy.
This means that experts must work more interdisciplinary and the government must work across responsibilities and from an international to a local level."

Collaboration across subjects and countries

European topic centers (ETCs) are consortia of institutions from the different EEA member countries. Each topic center will assist EEA on different challenges and tasks within a given environmental area. The activities are derived from the EEA strategy and management plan.

The ETCs constitute interdisciplinary networks where experts from many countries meet and work together to find sustainable solutions for their topic area. This collaboration again helps build local competence on environmental and climate change and sustainable sectoral policies in the countries.

"We are all proud that NILU has been given the key responsibility to lead one of EEA's seven topic centers and, in addition, to participate as a partner in the ETC for Climate change Mitigation and Energy," says NILU's Managing Director Kari Nygaard.

"I would also like to thank the Ministry of Climate and Environment for their support in this important work of promoting knowledge of key environmental issues in Europe."

Large, interdisciplinary expert team

In total, sixty leading scientists and experts in air quality and air pollution, transport, noise and industrial pollution will work together to find solutions to the challenges assigned to the topic center.

The work is organized in three work packages. The first deals with data reporting, quality control and support, with emphasis on providing targeted and reliable data relevant to environmental and sectoral policies. Harmonizing the technical systems for data reporting is of high priority. Other important tasks are data collection and organization, quality assurance and control, and dissemination.

The main purpose of the second work package is environmental assessment related to the development and implementation of environmental policy.

"Here, we will contribute with assessments of status, trends and future scenarios, and advice on communication with different user groups," explains Bartonova.

"Today, private individuals and civil society engage more and more in environmental issues, so in addition to the "usual" ways of retrieving data, we also want to use citizen science to make assessments and advice as good and relevant as possible."

The third work package will ensure efficient implementation of the partnership agreement. It is about internal decision-making, internal and external communication structures, risk management, quality assurance and control.

"We will work closely with the European Environment Agency in the implementation of the ETC," says Bartonova, "and of course, with other topic centers to ensure effective synergies and coordination. It will all be very exciting!"

Kari Nygaard, Managing Director. Photo: Ingar Næss

The ETC/ATNI consortium

The consortium consists of eight organizations from Norway, Austria, Czech Republic, France, Greece, Spain and the United Kingdom. Sixty leading scientists and experts in air quality and air pollution, transport, noise and industrial pollution will work together to find solutions to the challenges assigned to the topic center.

Partners	Land
NILU – Norwegian Institute for Air Research (leader)	Norway
Aether Limited	United Kingdom
Czech Hydrometeorological Institute (CHMI)	Czech Republic
EMISIA SA – Société Anonyme of Environmental and Energy Studies and Software Development	Greece
Institut National de l'Environnement Industriel et des risques (INERIS)	France
Universitat Autònoma de Barcelona (UAB)	Spain
Umweltbundesamt GmbH (UBA)	Austria
4sfera Innova, S. L.U.	Spain

NILU and the Norwegian Ski Federation work together against fluorine

The Norwegian Ski Federation introduces a ban on fluorinated ski waxes for age-specific classes up to and including 16 years. To control that the ban is complied with, they will use a new method called SkiFT, developed by NILU - Norwegian Institute for Air Research.

"Fluorine-containing substances give exceptional low friction, but inhaling them are very dangerous for your health, and also harmful to the environment. That is why we are very pleased that the Norwegian Ski Federation now takes steps to end the use of these environmental toxins in a sport we like to perceive as healthy for both people and nature," says senior scientist Martin Schlabach from NILU's department of Environmental Chemistry. He has been the prime mover for developing this new method.

Simple and quick

In collaboration with the German Fraunhofer Institute for Process Engineering and Packaging IVV, NILU has developed SkiFT, a simple and fast method for testing ski waxes during competitions. The test uses a special tape, sampling residues sitting on the surface of the skibase. The exposed tape is then sent for analysis, which for the time being takes a week's time. Thus, it is not possible to reveal use of fluorinated waxes on the spot, but the participant's association will receive the results later and can follow up. There will be no disqualification or punishment of young ski enthusiasts long after the race has been completed.

"The method is simple, it can be carried out under real conditions, and it requires little adaptation of existing measuring instruments and methods," explains Schlabach. "It was the method we had the most faith in during development, and we now look forward to further implementation of this method in cooperation with the Norwegian Ski Federation.

Hopes for a total ban

Back in 2015, scientists from NILU and the Norwegian Institute for Nature Research (NINA) first found that earthworms from Voksenkollen in Oslo was full of fluorine substances. The conclusion was that these findings could be attributed to the use of fluorinated substances during ski races in the area.

As of today, there are several hundred different fluorinated substances, and new ones are steadily developed. Many of them can also be used to improve ski waxes - and thus also the results. That is why Schlabach points out that a ban must apply to the whole group of fluorinated substances.

"Banning it for children and teens is a start," says Schlabach, "but I'm hoping for a total ban. It is the only way we can prevent these fluorine containing compounds from harming both humans, the environment and the ski sport itself."

Senior Scientist Martin Schlabach.
Photo: StudioF2, Ingar Næss

Photo: Knut Kristoffersen

Key figures

Extract from the annual statement: All figures in MNOK

INCOME STATEMENT	2018	2017
Project revenue	154,0	149,9
Basic grant, strategic institute initiatives included	31,3	29,4
National tasks and assignments	15,8	16,3
STIM-EU	4,6	4,3
Other operating income	0,1	0,1
Operating revenue	**205,8**	**200,0**
Wages and social expenses	-142,9	-136,6
Direct project expenses	-26,0	-24,6
Other expenses	-39,5	-35,7
Operating profit	**-2,6**	**3,1**
Net financial items	0,2	0,3
Tax	-0,7	-2,0
Profit for the year	**-3,1**	**1,4**

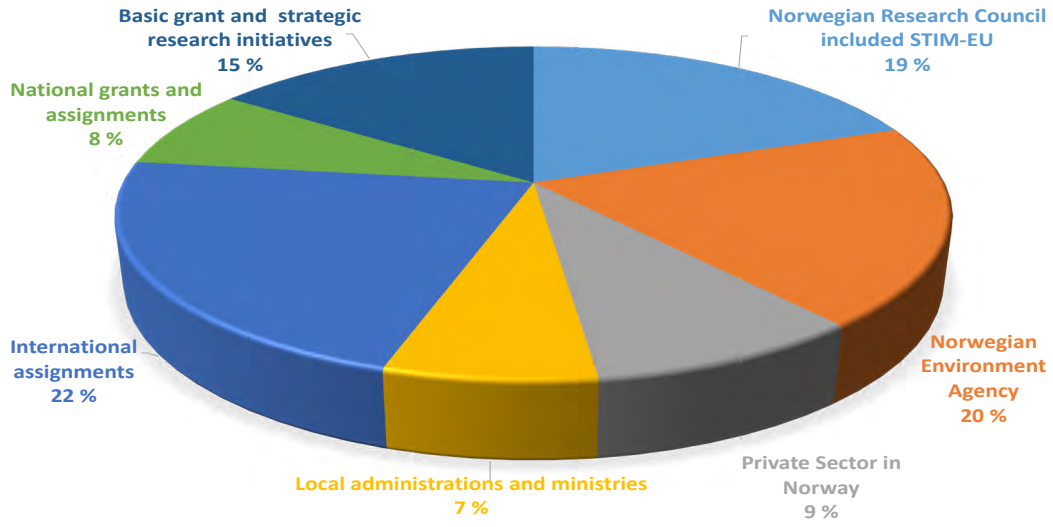
BALANCE SHEET	31.12.18	31.12.17
Fixed assets	102,1	98,7
Current assets	85,9	100,5
Total assets	**188,0**	**199,2**
Total equity	120,7	123,8
Short-term liabilities	67,3	75,4
Total equity and liabilities	**188,0**	**199,2**

NUMBER OF MAN-YEARS	2018	2017
Total	160	162
– whereof research man-year	103	104
– whereof man-years of other personnel	57	58
Turnover per research man-year	**1 998**	**1 923**

NUMBER OF EMPLOYEES	31.12.18	31.12.17
Total from over 20 different nations	175	171
– whereof women	92	86
– whereof men	83	85
Number of employees holding a doctorate	**69**	**69**

PUBLICATIONS AND DISSEMINATION	2018	2017
Scientific articles and chapters	122	130
Lectures and posters	194	196
NILU reports	39	45
EMEP/CCC reports	4	4
External reports	14	41
References in the media	553	372
Followers on Facebook	1080	946

Project portofolio – Percentage 2018



NILU – Norwegian Institute for Air Research

NILU – Norwegian Institute for Air Research is an independent, nonprofit institution established in 1969. Through its research NILU increases the understanding of climate change, of the composition of the atmosphere, of air quality and of hazardous substances. Based on its research, NILU markets integrated services and products within analyzing, monitoring and consulting. NILU is concerned with increasing public awareness about climate change and environmental pollution.

NILU's values: Integrity - Competence - Benefit to society

NILU's vision: Research for a clean atmosphere

www.nilu.no

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