



CENTRE FOR BIOGEOCHEMISTRY IN THE ANTHROPOCENE

ANNUAL REPORT 2019



UiO : University of Oslo

We study interactions
and feedbacks between
climate carbon cycling
and ecosystems in
northern latitudes.

Editor-in-chief Jan Heuschele

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Cover page

Thawing permafrost peatland near Áidejávri, Finnmark

Image credit: Sebastian Westermann

Drone pilot: Trond Eiken

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CLIMATE, ECOSYSTEMS, AND THE FUTURE RISKS



The Centre for Biogeochemistry in the Anthropocene (CBA) is up and running – at a good pace. While the CBA was initiated in 2018, 2019 was the real start-up year, and by the start of 2020, many activities will be consolidated, and new will come. Strictly speaking, CBA is actually continuing research that already was in good pace at the three involved departments; Biosciences, Chemistry and Geosciences with affiliated projects and partners. CBA also covers a range of scales in space and time, from molecular and genomic processes in microbial communities to large scale regional or even global models related to climate forcing and climate responses in northern regions (covering atmosphere, tundra, boreal forests and vegetation, wetlands, lakes and coastal areas). The idea behind CBA is thus to merge scales, projects, people and ideas since the complex problems involved in climate, elemental cycling and feedbacks no doubt require a broad multidisciplinary effort. CBA should thus provide an added value and both deeper and broader insights. As the attached list of scientific publication

should witness, CBA does indeed provide a strong, scientific output already. We also realise that doing good, basic science is just part of our mandate. Hence we should also be innovative and make a difference by delivering good education, and in fact, the new, joint course in biogeochemistry that was first held in 2019 was very well attended and received. Last but not the least, CBA should be actively engaged in dissemination, public debates and even political debates, popular science writing, public lectures and thus be involved in setting the agenda on relevant issues related to climate, CO₂ sequestration and greenhouse gas release in natural systems, northern ecosystem processes and the risk of feedbacks or even tipping points from these systems. A large number of talks, popular outreach and books can also be found in this report, witnessing that CBA already takes this task seriously.

Biogeochemistry is a complex and, to many, unknown field. It is truly interdisciplinary, covering processes in physics, chemistry, geology, hydrology,

meteorology and biology across systems and scales. This not only involves the cycling of carbon, but multiple elements tied together in complex cycles. However, a proper understanding of these processes is imperative for understanding climate drivers and responses, the resilience and robustness of natural systems and thus, the risks we are facing in the Anthropocene. While this concept or era, the Anthropocene, still is disputed, we have chosen this to use this term, not because it is important per se, but rather as a reflection of the massive human footprint on the planet.

A take-home message is that Earth is unique, it as a thermodynamically unstable planet – thanks to life itself. Life created over millennia the almost perfect conditions for life on this planet, which is why healthy ecosystems are mandatory to maintain these conditions on which we all depend. The planned, annual (and very well attended) CBA lecture in late fall 2019 by Tim Lenton addressed exactly these points under the topic “Climate tipping points”. A couple of months later,

Lenton and colleagues presented the topic again in a commentary paper in *Nature* that received a lot of attention. Clearly also the risks of tipping points and severe impacts of climate and ecosystem degradation can be disputed, and that is exactly the point. These are likely the largest risks that humans and ecosystems have faced in modern history, and both the research and discussions related to this is indeed where CBA aims to contribute.

Finally, we realise that natural sciences alone cannot solve these challenges, and hence we also seek cooperation with social and political sciences and beyond. CBA also aims to be instrumental in implementing several of the UN sustainability goals at UiO. Then let this report speak for itself with regard to the activities so far.

It is both a privilege and a great inspiration, and gives a sense of meaning, to be involved in the establishment of CBA. We look all forward to 2020 and the years to come.

Dag O. Hessen

OUR MISSION

MISSION

We study interactions and feedbacks between climate, carbon cycling and ecosystems in northern latitudes

We assess and predict changes in global carbon cycling, which is a crucial requirement to develop strategies to counter anthropogenic climate change.

We educate the next generation of climate scientists in the fields of biology, chemistry and geology.

We engage the public to implement strategies that help society and ecosystems reverse or adapt to climate and environmental changes

VISION

Our shared vision is

- to develop and deploy cutting-edge science to understand biogeochemical cycles in a changing anthropogenic world.
- to develop strategies to help society and ecosystems reverse or adapt to climate and environmental changes.

VALUES

We want to achieve excellence through

- Scientific rigorousness and openness
- Ethical practices in all areas of our endeavour
- Scientific accountability
- Respect, professionalism and dedication
- Sense of responsibility to transfer knowledge to the public
- Sharing of best practices and working as a team

MANAGEMENT STRUCTURE

CBA is a joint operation between the Department of Biosciences, Geosciences, and Chemistry. This important interdisciplinary element of our centre is reflected in both the leader group and the board.

THE LEADER GROUP

CBA is led by **Dag O. Hessen** (Biosciences), who is joined by **Rolf David Vogt** (Chemistry) and **Frode Stordal** (Geosciences) in the leader group.

THE BOARD

• **Brit Lisa Skjelkvåle** (Geosciences),
• **Jo Døhl** (Geosciences),
• **Rein Aasland** (Biosciences)
• **Solveig Kristensen** (The Faculty of Mathematics and Natural Sciences) and the **leader group**.

THE SCIENTIFIC ADVISORY GROUP

• **Tim Lenton** (University of Exeter, Global Systems Institute),
• **Marten Scheffer** (Wageningen University and Research)
• **Vigdis Vandvik** (Bjerknes Centre for Climate Research)

RESEARCH HIGHLIGHTS

CLIMATE, MICROBIAL METABOLISM, AND GREENHOUSE GASES



The research at CBA covers both theory and models, lab-work and fieldwork. As part of the international project on arctic biodiversity (Scenarios of freshwater biodiversity and ecosystem services in a changing Arctic), granted from Belmont Forum/The Research Council of Norway, a range of high Arctic ponds and lakes were sampled on Svalbard in August 2019. The project will also perform samplings in the Canadian and US Arctic and Greenland.

At Svalbard, ponds and lakes in the vicinity of Longyearbyen (78°13'N) and Ny-Ålesund (78°155'N) were sampled along gradients from glaciers to the fjord for nutrients, dissolved organic carbon, pH, chlorophyll, zooplankton, eDNA, RNA, dissolved gases (the greenhouse gases CO₂, CH₄ and N₂O).

Svalbard has experienced a striking change in climate over the past decades, with a 5,6 °C rise since 1961, and 100 months with temperatures above the “normal”. Part of this is explained by the reduced sea-ice. Most glaciers have retracted substantially, there is increased permafrost thaw and more rainfall, all of which affects terrestrial runoff to freshwaters and coastal areas. Also,

there has been a tremendous increase in the populations of geese which by grazing and defecation impacts land, lakes and ponds (Hessen et al. 2019).

Under these changing rapidly changing conditions, it is important to provide data on community composition, ecosystem change and a kind of baseline information for the future. In the Norwegian part of this study we thus provide baseline studies on community composition of organisms, extending previous data on invertebrates (Walseng et al. 2019) to include also the microbial component of the diversity. Given the prospects of permafrost thaw and methane release, we also performed

sampling of water chemistry and greenhouse gases (GHGs).

Such fieldwork offers an experience of breathtaking polar landscapes with glaciers, mountains and fjords, and wildlife such as the Svalbard reindeer, ptarmigans – and polar bears. It also offers first hand witnessing the striking action of climate change with retracting glaciers, melting permafrost and faunal changes. Some snapshots of the fieldwork are provided here.

Since sampling involves carrying equipment (and weapons) over extended distances, we developed sampling design that involved a

minimum of gear, yet a dry-shipper for snap-freezing samples for DNA, RNA and some chemical analysis is inevitable. The preliminary data show striking variability in nutrient levels (mostly related to bird impacts) and GHG concentrations, notably methane. The peak value of methane was a shallow site with pronounced bubbling of CH₄, indicating either underlying fields of gas (related to coal deposits) or thawing permafrost. The genetic analysis will take some time, and likely reveal the impacts of chronosequence (age) of the sites, productivity and bird impacts, and also link community composition to gene expression and GHG concentrations. A similar survey was also performed for mainland lakes during fall 2019 as part of the 1000 lakes survey.

Dag O. Hessen

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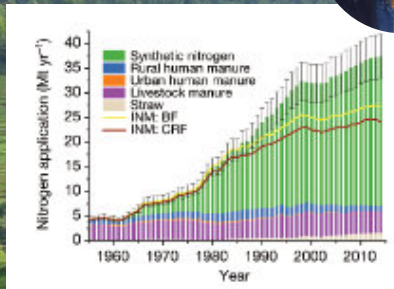
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THE NITROGEN CYCLE

Managing surplus N in China

Like most of the large, biogeochemical cycles, the nitrogen cycle has been profoundly altered by human activities. All of the Earth's major biogeochemical cycles have been strongly affected by human activities. Of particular note is the amount of reactive nitrogen (N) entering the environment which has increased from ~15 million tons (Mt) in 1860 to 156 Mt in 1995. Much of this increase is due to application of N fertilisers in agriculture which has risen from 12 Mt in 1961 to 110 Mt in 2013. Though critical for crop yields and food production, it also causes air pollution through the release of NH_3 and N_2O , and water pollution through leaching and runoff.

The short version of the N cycle is: Atmospheric N_2 is sequestered by some bacteria groups, among them blue-green bacteria, and this nitrogen fixation acts as the original springboard for almost all biologically available N—and thus for all additional life. Breaking N_2 's triple bond is no trivial task, it requires a decent amount of energy, the delicate enzyme nitrogenase, and the absence of oxygen. Bacteria that perform this feat in the presence of O_2 , for example, on the surface of ocean, lake, or soil, perform the job within specialised cells with oxygen-free interiors. Nitrogenase creates ammonium (NH_3), which is used by plants as the raw material for amino acids. At that point, N makes its way through the food chain. When members



of the ecosystem die and decay, proteins and other materials containing N are broken down and can be absorbed again. Animals, of course, also need to rid themselves of nitrogenous waste products; humans do this via urine. After some trifling modifications, urine is once again accessible to plants. Reduced N in dead organisms and material will greedily be exploited by other bacteria groups that oxidise N in several steps: first into nitrite (NO_2) and then nitrate (NO_3) in a two-step denitrification process. Nitrate is the second key form of N that plants can utilise, but a portion of this will again be taken up by other bacteria groups that perform nitrate reduction. NO_3 via NO_2 and N_2O back into N_2 and the circle is closed.

We have significantly impacted the N cycle, and currently human fix more N_2 than all the natural processes, and there are two particular reasons for this. Every combustion process not only forms CO_2 but also oxidises N_2 to NO_x (the generic

term for NO and NO_2). Multiple processes can transform NO into NO_2 , and NO_2 reacts with water to form nitric acid (HNO_3) in the atmosphere. This compound can travel large distances before it is deposited, where it has two effects: it acidifies and it fertilises and often over-fertilise ecosystems on land and sea.

Our second key intrusion into the N cycle is the fertilisation industry's Haber-Bosch process, where ammonia is produced by electro-shocking hydrogen derived from methane and N_2 from the air. This is a key factor in the green revolution, but the flip-side of the coin is that over-fertilisation in agriculture yields an unintended and often problematic increase in the polluting of waterways and coastlines. The other side-effect is large quantities of ammonia that vaporise from farmland and animal manure as it is spread. This ends up in the atmosphere and is distributed by the same winds as NO_x and HNO_3 , falls with the same

precipitation, and produces the same consequences: acidification and fertilisation.

China consumes about 31% of the world synthetic nitrogen (N) fertilisers and has profoundly altered N cycle. While the increasing N usage has boosted the food productivity, multiple sources of anthropogenic N caused severe groundwater and surface water pollution, as well as a strong increase in N_2O , a key greenhouse gas. In collaboration with Chinese colleagues we have looked into the potential remedies for the N-export to ecosystems, without going at expense of the food production. We assessed balances of multiple anthropogenic nitrogen sources during 1955-2014 in China. We found that synthetic nitrogen fertiliser contributes $45 \pm 3\%$ of current food productivity, but croplands contributes to $\sim 34\%$ of the total anthropogenic water pollution (14.3 ± 3.1 Mt N yr⁻¹). Neither cropland management nor wastewater treatment alone can reduce total N runoff in China sufficiently. Better cropland practices could cut $\sim 22\%$ off current surplus nitrogen. Wastewater treatment cost \$20.8 billion and 13.7 billion kWh energy, but only removed 0.7 ± 0.1 MtN in 2014. Restoring the water environment requires different provincial responses, but the national nutrient-recycling rate should be recovered from current 36% to 88% or higher. Nutrient recycling was thus found to be much more economically efficient than relying on waste treatment.

Dag O. Hessen

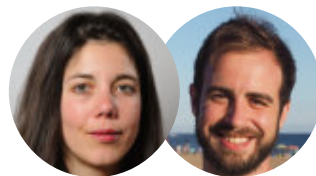
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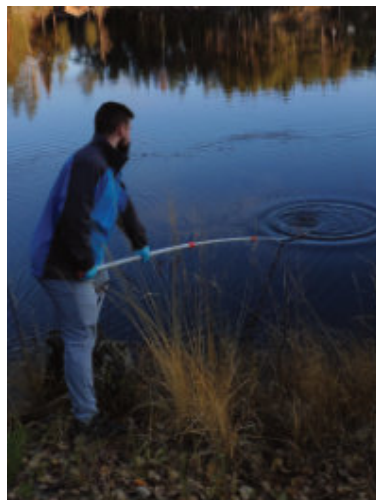
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100 LAKES

Documenting environmental change in Scandinavian lakes



From 1960, freshwater bodies in southern Norway experienced a decrease in pH due to acid rain. In order to monitor the status of the Norwegian lakes, several national surveys have been conducted over the whole Norwegian territory. A first one was done in 1986, covering 1005 lakes. It was repeated in 1995 over 1006 lakes, as part of a larger project aiming at evaluating the impact of acid rains in Fennoscandia, Iceland, Denmark and Svalbard. These 1006 Norwegian lakes have been sampled again in autumn 2019, to get a new overview of their chemical and ecological status in a context of changing climate. NIVA implemented this project and, in October and November, two helicopters covered the whole Norwegian territory from North to South collecting water samples.



In close cooperation with NIVA, the CBA conducted a complementary survey in 73 of the 1006 lakes from southern Norway. The aim was to collect supplementary samples to provide additional parameters, from those which required immediate handling of the samples (e.g. DNA), to those requiring larger volumes of water, what was not possible with a 2-minutes helicopter stop. A total of 17 people from the CBA took part in the sampling, which started on October 1st and ended on November 10th. But the sampling itself is only the tip of the iceberg: upstream, the coordination between the departments of Biology and Chemistry, as well as NIVA, was necessary to come up with the right amount of sampling equipment,

select the lakes or define the parameters to be analysed. Downstream, tenths of parameters were measured, both in biology (gas concentrations, bacterial quantification, DNA...) and in chemistry (pH, ions, trace metals, biodegradability...). At this moment, most of the analysis has been conducted, and we are now in the process of consolidating the database, to make it easily accessible for further works.

Thanks to the latitudinal variability of Norwegian lakes, and to the wide range of analyses that were conducted after the fieldwork campaign, the CBA will provide an extensive dataset, allowing to the society to have a deeper understanding of environmental changes in Norway.

Camille Crapart and
Nicolas Valiente Parra



PEEL RIVER EXPEDITION 2019

Sampling from the source to the Arctic ocean



Thawing of permafrost can release organic carbon and sediments to creeks and rivers that not only changes local ecosystems, but also impacts the carbon balance of the Arctic Ocean.

To better understand the fate of carbon in permafrost ecosystems, an international team travelled the 600km long Peel River in Northern Canada in canoes from its source to the Arctic Ocean, taking several hundred samples from streams and rivers (bottom photo). Permafrost thaw slumps (top photo) deliver large amounts of sediment to the Peel River and its tributaries (middle photo), transforming the initially crystal-clear stream (large photo) to a wide sediment-laden river. The samples will be analysed in the EU-funded Nunataryuk project.

Sebastian Westermann from CBA was one of the organisers and took part in the campaign, together with more than ten researchers and volunteers from the Netherlands, Germany, Canada and Norway.

Sebastian Westermann

CHINA'S ENERGY POLITICS AND CO₂-EMISSIONS



A cooperative effort has addressed the energy politics and CO₂-emissions in China over the past 40 years, showing a tremendous increase in energy use along with an increased GDP, an increased energy efficiency and more use of renewable energy, but still a strong increase in CO₂-emissions. China has become the largest CO₂ emitter in the world and presently accounts for 30% of global emissions. The major drivers of energy-related CO₂ emissions in China from 1978 when the reform and opening-up policy was launched, to the 2018-situation is analysed. We found that 1) there has been a 6-fold increase in energy-related CO₂ emissions, which was driven primarily (176%) by economic growth followed by population growth (16%), while the effects of energy intensity (-79%) and carbon intensity (-13%) slowed the growth of carbon emissions over most of this period; 2) energy-related CO₂ emissions are positively related to per capita gross domestic product (GDP), population growth rate, carbon intensity, and energy intensity; and 3) a portfolio of command-and-control policies affecting the drivers has altered the total emission trend. However, given the major role of China in global climate change mitigation, significant future reductions in China's CO₂ emissions will require transformation toward low-carbon energy systems.

Our analysis suggested that, since the launch of the reform and opening-up policy, China has enacted, reinforced, or adjusted economic policies to satisfy developmental and environmental needs. We identified 4 drivers that together influence the dynamic trend of China's CO₂ emissions. In addition, this analysis may be helpful in assessing the long-term trends and goals of CO₂ emissions. The Chinese government pledged to continue with economic

reform and an open market at the 40th anniversary of China's reform and opening-up policy. This means that the policy environment for economic growth and energy efficiency improvement will exist for a long time, and a medium-high GDP growth rate is both possible and feasible. A less strict family planning policy did not trigger an increase in the fertility rate, but the adjustment of the family planning policy can boost labour resources and delay the process of population ageing. In this context, many research institutes have predicted that China's population will continue to grow until at least 2030. Thereby, economic growth and population size will remain, driving the increase in CO₂ emission in the long term.

By 2018, the fractions of coal and oil still constituted approximately 60 and 20% of the total energy mix respectively, and the growth in volume have cancelled out the positive impacts of increased efficiency. Still, as with the case of nitrogen, China is a key player for the future global development, and in many ways holds the key to the planetary future (cf. the newspaper chronicle in this report), hence a collaborative effort on this global biogeochemical issue will be of major interest.

An open access paper on this was published as a Perspective paper in PNAS by the end of 2019, appearing in the printed issue early 2020.

Dag O. Hessen

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THE RESEARCH AREAS OF CBA

At the Centre for Biogeochemistry in the Anthropocene, our goal is to assess and predict changes in global carbon cycling, a crucial requirement to develop strategies to counter anthropogenic climate change. We integrate research at various scales from the molecular level to organisms, catchments, and up to regions.

ATMOSPHERIC CHEMISTRY



The Atmospheric Chemistry Group at the Department of Chemistry studies the composition, sources and transformation of organic molecules in the Earth's atmosphere. The group develops and deploys highly advanced mass spectrometric instrumentation for achieving its research goals.

In 2019, the group carried on its long-year collaboration with the Technology Centre Mongstad (TCM) where Norway is developing world-leading knowledge for capturing carbon dioxide (CO₂) from industrial flue gas. We measured the amount and fate of amines that are released into the atmosphere when CO₂ is captured, helping to make this technology environmentally safe.

We also participated in the NOAA-NASA field experiment FIREX-AQ (Fire Influence on Regional to Global Environments Experiment - Air Quality). Our mass spectrometer was deployed aboard NASA's DC-8 Flying Laboratory to measure emissions of ammonia from wildfires in the United States. Ammonia plays an important role in the formation of atmospheric particulate matter and in the atmospheric deposition of nitrogen.

Armin Wisthaler

<https://catchingourfuture.com/2018/08/22/arm-amine-research-and-monitoring/>
<https://www.esrl.noaa.gov/csd/projects/firex-aq/>



Image credit: Technology Centre Mongstad



A Proton-Transfer-Reaction Mass Spectrometer measuring the Earth's atmospheric composition aboard NASA DC-8 Flying Laboratory

SOIL-WATER INTERACTIONS, FATE AND FLUX OF DISSOLVED ORGANIC MATTER AND KEY ELEMENTS



At CBA, we study the biogeochemical processes governing mobilisation, transport, fate and effect of chemical compounds in the environment. Our focus is on the interactions between soil and water, figuring out the role of the watershed in determining spatial and temporal trends in surface water chemistry. Dissolved natural organic matter (DNOM) is a key explanatory factor in the boreal domain. Fluxes of this DNOM have doubled in boreal watercourses as documented in southern Scandinavian countries, Scotland and NE America. This has had profound effects on cycling of carbon, as well as associated elements, such as reactive nitrogen and phosphate. Furthermore, effects on the physical and geochemical freshwater habitat are profound, causing shifts in trophic levels and biodiversity. The causes for this increase is in the past related to decreased acid rain, while increased biomass due to changes in land-use, as well as climate change, are becoming increasingly important governing drivers.

By using chemistry knowledge to understand the links, and recognising that in the environment everything is connected, we conceive that the incredible up 90% decrease of acid sulphur deposition has also led to more eutrophication. The associated increased flux of DNOM is mobilising large pools of heavy metals, including mercury (Hg), in our forest floors. On the one hand, DNOM enhances bioavailability of Hg by promoting methylation, while on the other hand it serves as a strong detoxifier by chelating toxins to large refractory organic moieties.

Understanding the biogeochemical processes governing responses to changes in environmental drivers and pressures enable us to predict future effect of environmental changes, thereby enabling environmental resource managers to make knowledge based decisions, and decision makers to make the required adaptations, ensuring a more sustainable use of our eco-system services.

Rolf D. Vogt

DECLINING CALCIUM IN NORTHERN SURFACE WATERS

Towards a faunal osteoporosis



Currently there are two major climate-driven trends that profoundly affect lakes and rivers over large parts of the boreal biome; increased levels of dissolved organic carbon (DOC) and decreased levels of calcium (Ca). To a large extent these changes are driven by the same mechanisms, such as direct and indirect effects of climate change, and notably hydrology and reductions in acid deposition.

Temperature and precipitation dependent Ca mobilisation from rocks and soil to biota and aquatic environments is a crucial precondition for healthy ecosystem functioning. The current recovery from acidification of boreal regions on crystalline rocks has however revealed a somewhat paradoxical ecosystem response, characterised by striking base cation declines, notably Ca. The downward trend for Ca in soil water, rivers and lakes primarily reflects the combined effect of reduced mobilisation and depletion of base cation reservoirs on soil exchange sites, where export rates under changing climate increasingly exceed weathering rates. The decline has received much attention as a potential threat to the biota of Canadian and North-American lakes, but is also prominent in Europe, notably over southern Scandinavia and the UK.

Climate affects the flux and concentrations of Ca (and other ions and DOC) via three major mechanisms: 1) increased precipitation and runoff

that potentially will increase the overall wash out of Ca, but also dilute the concentrations; 2) increase in temperature which affect concentrations of mobilised Ca via weathering rates, and also indirectly by 3) promoting vegetation changes, where the net effect depends on the balance between weathering and uptake rates and hence forest development and forestry practices.

The impact of runoff and hydrology on Ca concentrations is crucial and will likely respond in similar ways as dissolved organic matter, where a wetter climate may increase DOC in dry regions, while have no or negative effects in wet regions. Such mobilising-dilution trade-offs of key elements from catchments is a less explored effect of climate and their dependence and responses to climate change needs more attention. Recently, spatial trends in Ca and drivers of decreasing Ca-concentrations were assessed using a 30-year time series for 70 Norwegian lakes for which there has been regular, annual monitoring of post-acidification recovery (Hessen et al. 2017). These lakes span a wide latitudinal and longitudinal gradient and revealed a striking decrease in Ca-concentrations towards critically low levels for biota. A conclusion was that biogeochemical Ca budgets are highly climate sensitive. Key drivers were identified as runoff, temperature, S-deposition and vegetation cover.

Calcium is an essential element for almost all living organisms. It is essential to invertebrates with a calcified exoskeleton as well as for bony structures in vertebrates. Ca deficiency in soft water localities may be a major determinant to success and distribution of a wide range of organisms, from invertebrates to fish and birds. Many northern areas have very low levels of Ca, and even lower levels may have strong impacts on the biota and ecosystem processes.

In a global study we examined variation and controls of freshwater Ca concentrations, using 440 599 water samples from 43 184 inland water sites from 57 countries. We found that the global median Ca concentration was 4.0 mg L⁻¹ with 20.7% of the water samples showing Ca concentrations ≤ 1.5 mg L⁻¹, a threshold considered critical for the survival of many Ca-demanding organisms. Spatially, freshwater Ca concentrations were strongly and proportionally linked to carbonate alkalinity, with the highest Ca and carbonate alkalinity in waters with a pH around 8.0 and decreasing

concentrations towards lower pH. However, on a temporal scale, by analysing decadal trends in >200 water bodies since the 1980s, we observed a frequent decoupling between carbonate alkalinity and Ca concentrations, which we attributed mainly to the influence of acid deposition in the landscape. At present, carbonate alkalinity is increasing or remains constant, while Ca concentrations in many freshwaters are rapidly declining towards or even below pre-industrial conditions as a consequence of recovery from anthropogenic acidification. Thus, a paradoxical outcome of the successful remediation of acid deposition is a globally widespread freshwater Ca concentration decline towards critically low levels for many aquatic organisms.

Dag O. Hessen

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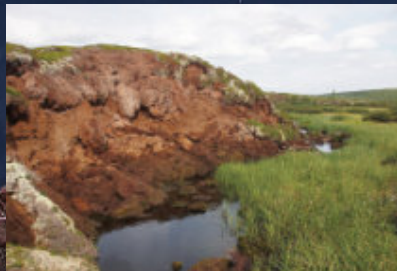
See also (in Norwegian): <https://www.aftenposten.no/viten/i/JAQP/vannet-blir-brunere-og-kalkinnholdet-synker>

PERMAFROST RESEARCH



Permafrost soils store enormous amounts of organic material that are presently still locked away in a frozen state. However, permafrost is warming and thawing at a high rate, threatening to release additional greenhouse gases in a process termed the “permafrost-carbon feedback”. The Department of Geosciences has a long history in permafrost studies, combining field measurements, remote sensing and numerical modelling. In CBA, we are joining forces with the Bioscience and Chemistry Departments to investigate the links between permafrost thaw and the carbon cycle in different ecosystems. Our particular focus will be on permafrost peatlands in Northern Norway, where rapid permafrost thaw is occurring already today. These easily accessible Norwegian sites provide us with the unique opportunity to study permafrost processes in “real-time” that are likely to affect large areas in Siberia and Alaska in a future warmer climate.

Sebastian Westermann



MICROBIAL GENOMICS AND METABOLISM



Microbes are all around us and shape the state of our planet by facilitating the storage, transport, and turnover of key elements. While microbial activities are key to global climate and local ecosystems water quality, theory and models that integrate microbial influence in ecosystem, landscape and earth system models still need to be developed. Reasons for this have been methodological limitations to study the immense diversity and functional role of natural microbial communities. However, this has now dramatically changed since advancements in sequencing technologies, functional profiling techniques and single cell approaches have revolutionised the way microorganisms can be studied.

Tying in with this recent revolution we explore the ecological and evolutionary dynamics of the complex microbial compartment in the aquatic environments using 'omics' approaches and deep functional profiling of microbial communities and single cells. We integrate high-throughput laboratory experiments and field data from study sites ranging from arctic to boreal lakes, rivers and wetlands. Here, we use the analogy that an ecosystem,

similar to a living cell, has a collective metabolism based largely on the dynamic genetic blueprint and expressed phenotypes of microorganisms that control most fluxes of energy and matter. Starting from genome-based hypotheses which are simultaneously tested by in situ functional and culturing-based assays, we intend to predict ecosystem processes from the behaviour of the complex microbial compartment. Ultimately, we aim to facilitate engineering of complex microbial (eco)systems.

Alexander Eiler

THE UMBRELLA PRINCIPLE

Several affiliated projects and facilities come together at CBA

The Centre for Biogeochemistry is a multidisciplinary centre that connects researchers from biology, geosciences and chemistry.

These disciplines can often use the same techniques to approach and solve scientific questions. CBA is associated with UiOs Phytotron and the CLIPT lab, two facilities that provide critical services for many of CBAs scientific endeavours.

The spirit of cooperation and communication is also visible through projects that are either affiliated with or directly hosted by CBA. Read more about it on the next pages.

THE PHYTOTRON



The Plant Lab at IBV consists of 16 fully climate controlled growth rooms, eight of which are inside a GMO containment zone (S3). In addition, there are six large climate controlled daylight rooms, where daylight enters through the walls and ceiling. The facility also has two freezer rooms and five rooms with only temperature control. Two systems of custom-built chambers for exposure to manipulated gas atmospheres are mounted, enabling experiments on the effects of ozone pollution (in the ppb range) or altered CO₂ concentrations (in the ppm range). Performing experiments with plants grown under controlled environmental conditions is valuable for testing hypotheses related to plant responses to environmental factors, pollution factors or biotic interactions or for quantifying the responses to variations in such factors. Since the experiments can be conducted at any time of the year, regardless of the seasons outside, using the facility is time saving within a project period. The location at the university campus also allows frequent observations for studies of dynamic responses. One important aspect in scientific experiments is the repeatability, which is more easily achieved in experiments conducted in controlled environments than in the field.

Ane Victoria Vollsnes



THE CLIPT LAB

The CLIPT LAB'S (Climate Interpretation of Plant Tissues) contribution to CBA

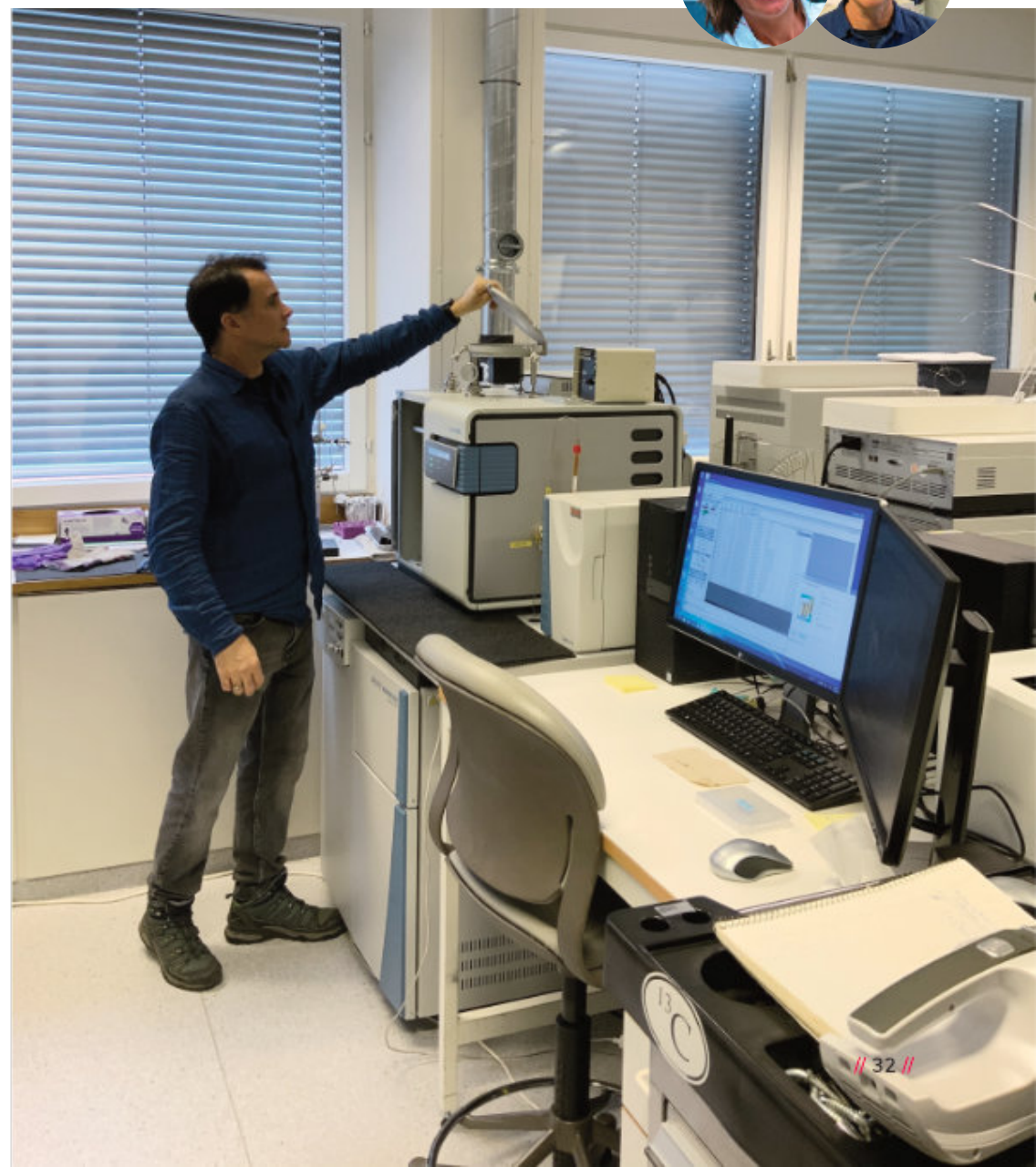
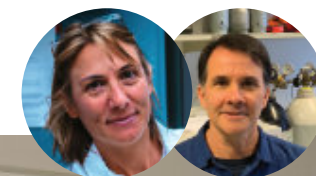
The new CLIPT Stable Isotope Biogeochemistry Lab is a state-of-the-art stable isotope laboratory and experimental plant growth facility that opened April 24, 2017 and has been actively forming collaborations with researchers from across the university in a diverse array of fields. Currently, we have 17 different PI's using the facility with 9 more in the planning stages to use CLIPT as a resource. Among these researchers are 11 that are part of CBA, coming from the Biology, Geology, and Chemistry departments.

The CLIPT lab is committed to providing high-quality stable isotope analyses of C, N, O and H across a variety of geological and biological substrates. Housed within the laboratory are two stable isotope ratio mass spectrometer (IRMS) systems that are capable of a wide array of sample-type analysis, ranging from rock and sediment, to plant and animal (including human) fossil and living tissues. A Delta-V Advantage IRMS (Thermo Scientific) is configured with an Elemental Analyzer Isolink System (Thermo Scientific) that provides bulk $\delta^{13}\text{C}$, $\delta^{15}\text{N}$, $\delta^{18}\text{O}$, and δD analyses on organic tissues. A Liquid Chromatography Isolink System (Thermo Scientific) is also configured with the Delta-V and provides compound specific $\delta^{13}\text{C}$ analyses on mixtures containing water soluble compounds such as sugars and amino acids. The second instrument, an Isoprime IRMS (Micromass, Ltd.) is configured with a modified Eurovector EA3000 elemental analyzer unit used for

$\delta^{13}\text{C}$ analysis of atmospheric CO_2 . Additionally, an HP6980 gas chromatograph is coupled to the Isoprime via a micro-combustion interface that enables $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ compound specific analyses for complex mixtures such as amino acid and fatty acid extracts from biological tissues.

Stable isotopes are a powerful tool for studying movement and transformations of elements through natural and human disturbed earth systems. The CLIPT lab is looking forward to growing into a central facility of CBA that is committed to support at all levels providing techniques for addressing CBA specific research questions. This includes working with principal investigators and their graduate students, in addition to providing opportunities for students at the beginning of their scientific career. For example, the CLIPT lab has actively supported the BIOS5412 class (Toxicants in Ecosystems and Humans: Exposure and Accumulation) by providing a guest lecture on stable isotope techniques, a lab demonstration and stable isotope analyses for the class projects. The CLIPT lab has also worked with several PI's and a graduate student growing plants under controlled pCO_2 conditions, with future plans to expand and study plant growth under environmental conditions that are predicted for the near future.

Anne Hope Jahren & Bill Hagopian



TERRESTRIAL ECOSYSTEM - CLIMATE INTERACTIONS OF OUR EMERALD PLANET

EMERALD is a national project funded by the Research Council of Norway. It is coordinated by Department of Geosciences (DoG), UiO. A substantial part of the budget is allocated to research in this department, and this activity is part of the work in CBA. Also, Department of Biosciences (DoB) and Natural History Museum (NHM) of UiO are partners.

Plants regulate the cycles of carbon dioxide and water, impact the composition of the atmosphere, and affect how the landscape absorbs or reflects sunlight. As such vegetation is not only shaped by climate, it also feeds back to the atmosphere and shapes the environment. An example of such feedback in the climate system is a change in the forest line due to climate change, which in turn affects the climate through changes in absorption of solar radiation, evapotranspiration, carbon sequestration and by influencing snow accumulation and ablation. Such feedbacks can be positive or negative, i.e. enhancing or counteracting the climate change signal, respectively.

EMERALD is highly interdisciplinary and it integrates and strengthens research groups in Norway studying the role of vegetation in the climate system. In particular the project aims to improve the understanding of high latitude ecosystems processes and their representation in global climate

models, integrating knowledge and data gained from observations and experiments. The focus is on boreal and Arctic ecosystems, such as evergreen trees, deciduous trees, shrubs, mosses and lichens.

The researchers in EMERALD especially works to improve the land module in the Norwegian Earth System Model, NorESM. Vegetation and many land surface processes in cold environments, such as Norway, are not well described in current climate models. EMERALD contributes to the improvement of the land module in NorESM, using data and knowledge from field-based ecosystem research. The long-term goal is to improve the projections of climate change for our northern regions.

Several research groups contribute key knowledge about the interaction between land surface processes, terrestrial ecosystems and the climate systems. EMERALD integrates, structures and develops this interdisciplinary field of research, by linking research groups working with models and field studies. This provides added value through joint field work and experiments, and coordinated modelling work. The UiO groups in the projects perform field work in Finse, Finnmark and on Svalbard, linked to existing projects and research infrastructure. Experiments are carried out in the phytotron in DoB.

EMERALD has a high focus on dissemination, in particular communication with the general public and policy and decision makers. Results are disseminated through the Norwegian Climate Service Center. A temporary exhibition in the Climate House in NHM, which will open in the spring of 2020, will exhibit EMERALD results.

Lena M. Tallaksen & Frode Stordal



Lena M. Tallaksen & Frode Stordal with the book 'The Emerald Planet' (Beerling/2007) which was an inspiration for the name of the research project. Photo: Terje K. Berntsen/UiO



Frans-Jan Parmentier maintaining the flux tower in Adventdalen, Svalbard, measuring fluxes of greenhouse gases.



Ane Vollsnes measuring photosynthesis and stomatal conductance in Crowberries in Finnmark. Photo: Frode Stordal/UiO.

OUTREACH ACTIVITIES

Our research outside the ivory tower

At CBA we love to engage in public outreach. Our researcher connect with the public through debates, presentations, newspaper articles, and other ways. On the following paper you will get a glimpse of our activities to present and explain the importance of our research to society. Make sure to visit also the section CBA in numbers to get a list of newspapers and presentations that happened in 2019.



Presentation of CBA at the UiO Science Library

In collaboration with the UiO Science Library, CBA had the "Klima, karbon og de store sammenhengene" (climate, carbon, and the big links) event at Blindern on the 30.4.2019. The dean Morten Dæhlen opened the happening and Dag O. Hessen, Frode Stordal and Rolf David Vogt introduced the scientific background, the structure, and the ambitions of the Centre for Biogeochemistry. In the following panel discussion, the participants elaborated on the pressing question of how our centre can best contribute to tackling the climate crisis and what its challenges are.



FORSKNINGSTORGET 2019



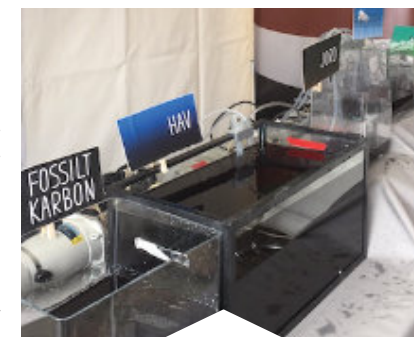
We were lucky to have had our booth at Forskningstorget in Oslo from the 19th and 20th of September. Together with 32 other research groups, we presented our research topics in the context of this year's theme "Environment". Forskningstorget ("The science fair") is a part of Forskningsdagene ("Science days") in Oslo. We had lots of visitors and perfect weather conditions throughout the weekend.

In our booth, we focused on the carbon cycle. We had three main stations and a large background illustration that placed the human influence on the carbon cycle in the context of the natural cycles.



The greenhouse effect We used a physical model of the atmosphere to explain the greenhouse effect. Grey opaque disks illustrated greenhouse gases and transparent disks molecules such as atmospheric oxygen and nitrogen. The visitors could simulate infrared radiation on its way through the atmosphere with a laser pointer. Greenhouse gases made it harder to "shoot" back into space as the radiation was absorbed on its way, compared to the "transparent" molecules. We placed a poster visualising and explaining the processes in the background of the installation.

CO2 chemistry Increased CO₂ levels in the air lead to more dissolved carbon in oceans and lakes. We had small experiments illustrating the mechanisms and the consequences it can have. In one, our visitors could test how the CO₂ in their breath acidifies the water. By blowing into a small glass with water, they could observe a colour change from blue to yellow, which indicated a reduction in pH. A second experiment showed the effect of acidic waters on limestone. A small amount of calcium carbonate is either mixed into carbonated water or with ordinary tap water. While it dissolves quickly in the first one, it does not in the latter, showing the erosive effect of acidic waters. To help with explaining the chemical processes, we also had an accompanying poster.



The carbon pump This station featured a simplified physical model of the carbon cycle, where black water represented carbon and aquaria the carbon pools. We scaled the volume of each aquaria the amount found in each carbon pools. A battery of peristaltic pumps and pipes transferred the "carbon" from one pool to the other relative to their natural rates. Like this, we visualised the exchange between the oceans, the atmosphere, the plants and the soils. An unconnected aquarium represented the fossil pools in the earth crust. To show the use and burning of fossil fuels, we transferred carbon from this container to the atmosphere. We excluded the carbon stored in sedimentary rocks, because the exchange with the other carbon pools is minimal.



POPULAR SCIENCE BOOKS

In a time of information overload, traditional books remain important in communicating the bigger picture



The many lives of carbon

The book is the story of the ubiquitous chemical element - carbon. It is a story of balance between photosynthesis and cell respiration, building and burning, life and death. Follow along with Dag O. Hessen and discover carbon in minerals, rocks, wood, and rain forests. He tells the reader how scientists are studying the carbon cycle, its role in the greenhouse effect, and the recent changes of the climate in the Anthropocene. Dag asks the burning questions of our time. How will ecosystems respond to global change, and how will this alter in return into our climate? How bad could it become and are ecosystems able to recover from these changes? Join Dag on his trip from atomic to planetary scales.

THE FUTURE

In 2020, two new projects will start under the umbrella of CBA.

A GREEN-BLUE LINK MADE BROWNER



How terrestrial climate change affects marine ecology

With climate warming, a widespread expectation is that events in spring, like flowering, bird migrations, and insect bursts, will occur earlier because of higher temperature. However, in coastal waters, a gradual delay in spawning time by 40 days occurred between 1877 and 1980, after which it started advancing again. Preliminary analyses suggest that large scale land-sea interactions are the reason that cod spawn later, and not earlier, in warm water.

The recent browning of lakes and rivers could be the crucial link between spring bloom conditions in coastal waters and the terrestrial ecosystem. While agricultural practices primarily drive nutrient loading, browning is climate-driven via increased precipitation and air temperature, stimulating plant and forest growth. Together with changes in land use, this results in an increased load of dissolved organic matter in lakes and rivers, which reduces water clarity. Eventually, coastal water clarity is reduced directly by dissolved organic matter or indirectly by eutrophication. Changes in the light regime can influence plankton growth and, in turn, the timing of events such as spring bloom and fish spawning. Since the 1980s, warmer temperatures have likely reversed these trends, making future projections dependent on strong interactions between multiple drivers.

Several CBA researchers will join the project led by Anders Frugård Opdal from the University of Bergen to uncover the underlying processes and mechanisms behind these land-sea interactions.

Tom Andersen

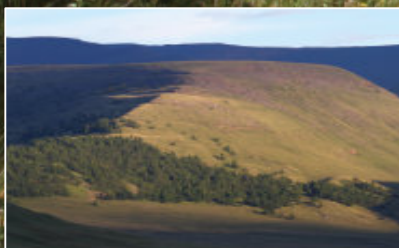
MONGOLIA

Uncovering the links between permafrost, grazing, and forest growth



In the 2019 round of the FRIKLIM solicitation of the Norwegian Research Council, the project “Permafrost4Life - Permafrost ecosystems entangled with human life in Mongolia - evaluating the impact of land use change in a warming climate” was selected for funding (lead Sebastian Westermann). In the project, CBA will work with Mongolian researchers to investigate the interplay between permafrost, water cycle and grazed ecosystems in central Asia. Organic-rich permafrost soils play a significant role as they sustain large herds of domestic animals and thus form the basis of the semi-nomadic lifestyle in rural areas. In Permafrost4Life, the vulnerability of these ecosystems to climate change and over-grazing will be studied with remote sensing, field experiments and modelling, working closely with Mongolian stakeholders towards sustainable land use practices.

Sebastian Westermann



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de Wit, Heleen; Braaten, Hans Fredrik Veiteberg; Gundersen, Cathrine Brecke; Krzeminski, Pawel; **Vogt, Rolf David.** 2019. Long-term Mercury records in a boreal lake: lake Processing and the role of organic matter. SETAC Europe 29th Annual Conference.

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Haaland, Ståle Leif; Eikebrokk, Bjørnar; Riise, Gunnhild; **Vogt, Rolf David.** 2018. Climate driven NOM development - Future browning of Western Scotland raw waters. Nordic drinking water conference (NORDIWA)

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Holm, Kirstin Marie; **Vogt, Rolf David; Håland, Alexander;** Rajakumar, Janaki. 2018. Biodegradability of Dissolved Natural Organic Matter. Nordic drinking water conference (NORDIWA)

CONFERENCE PRESENTATIONS

Nipen, Maja; Vogt, Rolf David; Borgå, Katrine; Haarr, Ane; Mwakalapa, Eliezer Brown; Schlabach, Martin; Bohlin-Nizzetto, Pernilla; Mmochi, Aviti John; Breivik, Knut. 2019. Spatial and temporal trends in e-waste related organic pollutants in a developing economy - A pilot study. SETAC Europe 29th Annual Conference.

Vogt, R.D. 2019. Climate change and DNOM in aquatic environment - The biogeochemistry of Dissolved Natural Organic Matter. Key note lecture at the IWA NOM7 Conference

Vogt, Rolf David; Haaland, Ståle Leif; Riise, Gunnhild; Bozhko, Ksenia; Eikebrokk, Bjørnar. 2018. Causes for increase in Dissolved Natural Organic Matter and changes in its quality. Nordic drinking water conference (NORDIWA)

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CBA IN THE MEDIA

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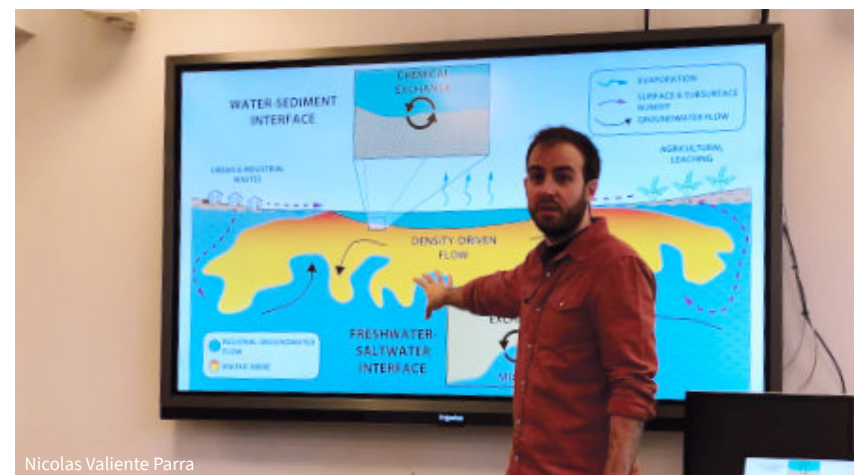
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PRESENTATIONS

by researchers and guests of CBA



Nicolas Valiente Parra

The biology of mercury methylation in the boreal landscape. Talk by **Stefan Bertilsson** (Uppsala university). 10.4.2019 at UiO

Biogeochemistry in the Anthropocene: Environmental Lunchtime Discussion. Public lecture by **Dag O. Hessen** (UiO) 10.4.2019 at Oslo School of Environmental Humanities

Vegetation-climate feedbacks. Lunch seminar by Frode Stordal (UiO). 23.4.2019 at UiO

Klima, karbon og de store sammenhengene. Public talk by **Dag O. Hessen**, **Frode Stordal**, **Rolf D. Vogt**, **Brit Lisa** (UiO) 30.4.2019 at the UiO science library

How reversed acidification and improved forest growth impacts water quality. Lunch seminar **Dag O. Hessen** (UiO) 14.5.2019 at UiO.

An introduction to PTR-MS and its application to Biogeochemistry. Lunch seminar by **Alexander Håland** (UiO). 28.5.2019 at UiO.

Climate tipping points. Public lecture by **Tim Lenton** (University of Exeter) 17.10.2019 at UiO

The evolution of the Earth system. Public lecture by **Tim Lenton** (University of Exeter) 18.10.2019 at UiO

Upscaling dissolved organic carbon from canoes - the Peel River 2019 expedition. Lunch seminar **Sebastian Westermann** (UiO) 15.11.2019 at UiO

Biogeochemistry in extreme environments: from saline to glacial lakes. Lunch seminar by **Nicolas Valiente Parra** (UiO) 20.11.2019 at UiO

Application of stable and radioactive isotopes. Lunch seminar **Xueqiang Lu** (Nankai University) 22.11.2019 at UiO

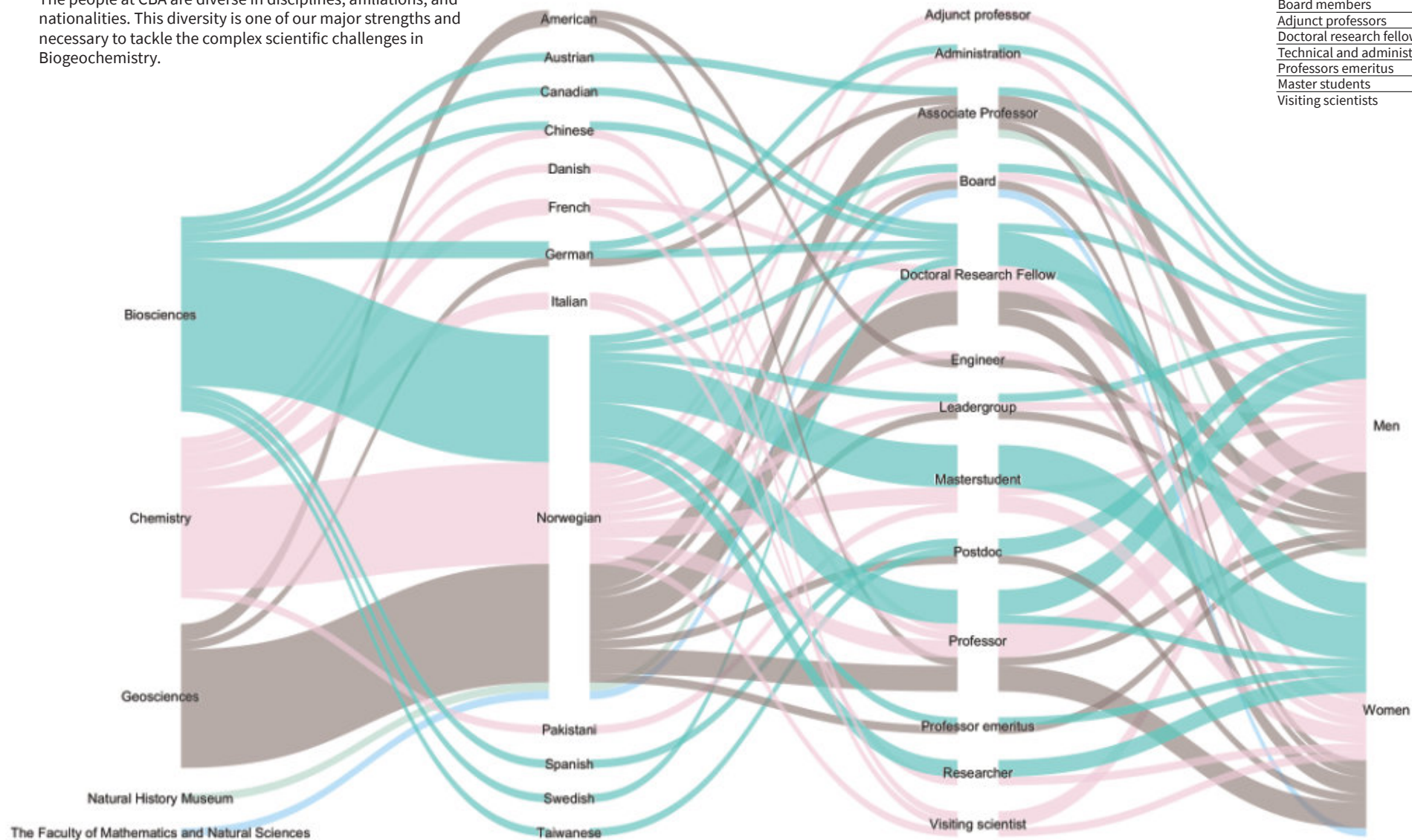
Electrochemical principle for wastewater treatment. Lunch seminar by **Minghua Zhou** (Nankai University). 22.11.2019 at UiO

Forskningsdagene: What is my phone doing in Africa? Public lecture and discussion **Katrine Borgå** (UiO). 26.11.2019 at Literaturhuset Oslo

Forest carbon uptake and the impacting factors. Lunch seminar by **You-Ren Wang** (UiO) 4.12.2019 at UiO

CBA IN NUMBERS

The people at CBA are diverse in disciplines, affiliations, and nationalities. This diversity is one of our major strengths and necessary to tackle the complex scientific challenges in Biogeochemistry.

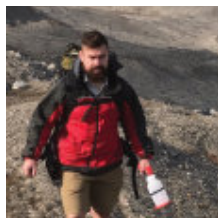


Professors	15
Associate professors	6
Researchers	3
Postdoctoral fellows	3
Board members	4
Adjunct professors	1
Doctoral research fellows	12
Technical and administrative staff	4
Professors emeritus	2
Master students	8
Visiting scientists	3

State 31.12.2019

THE NEW GENERATION

Get to know our PhDs and Postdocs



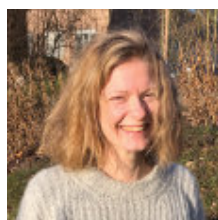
Laurent Fontaine

I study the functional and taxonomic diversity of freshwater microbes in the context of climate change and associated browning of waters in the northern hemisphere. A biologist by training, I have a background in microbial ecology and bioinformatics. I am currently completing my Ph.D at Universitetet i Oslo under the supervision of Alexander Eiler.

Elin Ristorp Aas



I have an MSc in meteorology, and I've been with the CBA as a PhD candidate since November 2018. I model soil carbon dynamics, with a special focus on microbial decomposition processes. These processes are a big source of uncertainty in the terrestrial part of Earth System Models. Through interdisciplinary collaboration we work to better understand and represent what goes on below ground in Boreal areas, and thereby improve model representation of soil-atmosphere carbon exchange.



Lina Allesson

I have a multidisciplinary background with degrees in physics and physical geography from Lund University in Sweden. Now I am doing a PhD in aquatic biogeochemistry here at the University of Oslo. The main question of my project is how lake water browning affects O_2 and CO_2 production and consumption. Ultimately, I study how the balance between the two may shift under the ongoing climate change with increased lake heterotrophy as a result.

Camille Crapart



I am a PhD student at the CBA since November 2018. I study the impact of climate change on dissolved natural organic matter in freshwaters, which allows me to go around collect water but mainly to work in the lab and with the data afterwards. I completed my master's degree in Paris both in environmental sciences and in international affairs before moving to Norway.

Sabrina Schultze



I am a PhD student with the AQUA Tox and CBA group with Katrine Borgå as my main supervisor. I study how different types of dissolved organic matter (aquatic derived vs. terrestrial derived) affect the uptake of contaminants via food in invertebrate marine or brackish water organisms and the resulting implications for food webs. Thus I combine ecotoxicological and ecological questions in my research. My background is in both terrestrial (MSc from the university of Tromsø) and marine ecology (BSc from the university of Bremen).



Maja Nipen

I'm a PhD student in environmental chemistry at UiO since January 2018. Prior to this I did my masters degree in analytical organic chemistry at the Norwegian University of Life Science and the Norwegian Institute for Air Research. In my current research I study organic pollutants associated with electronic waste, and environmental and anthropogenic processes governing the behavior of these pollutants. Fieldwork has been conducted in Tanzania, where air, soil and sediment core samples have been collected.

Jing Wei



I started my PhD on the 16th of September. And I am glad to do some research on the microbial community in the warming North, focusing on the impact of climate change on the aquatic microbial ecosystem and the feedback of the microbial community for example to melting permafrost and glaciers. I received my bachelor's degree in environmental science from Shandong University and received my master's degree in biological engineering from the University of the Chinese Academy of Sciences.



Lars-André Erstad

I'm a PhD student with CBA since Oct. 2018. I have a masters degree in environmental geology from UiO, where I worked on heavy metal leaching from acid producing black shale. Before starting my PhD I was working as an environmental consultant, focusing on soil/water contamination and black shale management in infrastructure projects.

Nicolas Valiente Parra



Born in Alcalá del Júcar (Spain), I have a multidisciplinary background combining forestry engineering, ecology and chemistry. I graduated in Forestry Engineering in 2010, and years later in Chemistry. In 2018, I completed my PhD at the University of Castilla-La Mancha about natural attenuation processes of nitrate in a hypersaline lake. At CBA, I am part of the BiodivERSA project, where we will evaluate biodiversity and functional trait patterns in relation to environmental drivers in Arctic freshwaters.

THE NEW GENERATION



Ane Haarr

Working with ecotoxicology, I am interested in how man-made contaminants behave in the environment and in biota. For my masters degree I studied levels and effects of contaminants in Arctic seabirds. My current PhD position in the interdisciplinary project AnthroTox has brought me to warmer regions of the world, more specifically Tanzania. Here, I investigate whether E-waste represent a pollution source to various coastal ecosystems by analyzing contaminant concentrations in fish, marine invertebrates, water, mangrove sediments, eggs and vegetables.

Thea Hatlen Heimdal

I completed my PhD at the Centre for Earth Evolution and Dynamics (CEED), UiO in 2018 where I studied the relationship between Large Igneous Provinces (LIPs) and environmental/climatic changes using a multidisciplinary approach (geochemistry, petrology, numerical modeling). Today I have a postdoctoral researcher position at CEED where I use carbon cycle models to explore the effects of carbon release from LIPs on the atmosphere and oceans. I study geological time periods in which the Earth underwent similar changes to those we are witnessing today.



You-Ren Wang

It is my pleasure to have the opportunity to join CBA since September 2019. I was born in Taipei, Taiwan, received bachelor's and master's degrees in Physics from National Taiwan University and a PhD in experimental astroparticle physics from the University of Wisconsin-Madison. Here in CBA, my ongoing project is the investigation of the relation between forest carbon uptake and its impacting environmental factors utilizing integrated measured and modelled data. Other projects include the modelling of the future status of lakes' physical dynamics under climate change.

Alexander Håland

I am doing my PhD in the Atmospheric chemistry group. My focus is on developing a technique to measure and characterise fluxes of atmospheric amines from both natural and anthropogenic sources. I have a bachelor's degree in geology and a master's degree in chemistry, where I studied the flux of humic matter in freshwater rivers in cooperation with NIVA. In the beginning of my PhD the focus was primarily on labwork and instrument development.

We now can measure even the smallest traces of amines in the atmosphere. The focus has therefore shifted to do field measurements. I just came back after a several week long measurement campaign around an oil refinery in Norway.



PEOPLE AT CBA CORE MEMBERS

First name	Last name	Nationality	Position	Institute	Section
Rein	Aasland	Norwegian	Head of Department	Biosciences	
Tom	Andersen	Norwegian	Professor	Biosciences	AQUA
Terje	Berntsen	Norwegian	Professor	Geosciences	MetOs
Katrine	Borgå	Norwegian	Professor	Biosciences	AQUA
Anders	Bryn	Norwegian	Associate Professor	Natural History Museum	GEco
Jo	Døhl	Norwegian	Head of Department	Chemistry	
Alex	Eiler	Austrian	Associate Professor	Biosciences	AQUA
Helge	Hellevang	Norwegian	Associate Professor	Geosciences	NATHYD
Dag Olav	Hessen	Norwegian	Professor	Biosciences	AQUA
Anne Hope	Jahren	American	Professor	Geosciences	CEED
Brit Lisa	Sjølkvale	Norwegian	Head of Department	Geosciences	
Frode	Stordal	Norwegian	Professor	Geosciences	MetOs
Lena Merete	Tallaksen	Norwegian	Professor	Geosciences	NATHYD
Einar	Uggerud	Norwegian	Head of Department	Chemistry	
Rolf David	Vogt	Norwegian	Professor	Chemistry	SMV
Ane Victoria	Vollsnes	Norwegian	Researcher	Biosciences	EVOGENE
Sebastian	Westermann	German	Associate Professor	Geosciences	NATHYD
Armin	Wisthaler	Italian	Professor	Chemistry	SMV
Erika	Zardin	Italian	Researcher	Chemistry	SMV

POSTDOCS, RESEARCHERS AND OTHER MEMBERS

First name	Last name	Nationality	Position	Institute	Section
Per	Aagaard	Norwegian	Professor emeritus	Geosciences	
Gabrielle	Adli	French	Visiting scientist	Chemistry	SMV
Lina	Alleson	Swedish	Doctoral Research Fellow	Biosciences	AQUA
Georg	Becher	Norwegian	Visiting scientist	Chemistry	SMV
Aud Else	Berglen Eriksen	Norwegian	Professor emeritus	Biosciences	Fytotronen
Sara Marie	Blicher	Norwegian	Doctoral Research Fellow	Geosciences	MetOs
Knut	Breivik	Norwegian	Adjunct professor	NILU/Chemistry	SMV
John	Burkhardt	Norwegian	Associate Professor	Geosciences	
Camille	Crapart	French	Doctoral Research Fellow	Chemistry	SMV
Lars-Andre	Erstad	Norwegian	Doctoral Research Fellow	Geosciences	Section of Geology and Geophysics
Laurent	Fontaine	Canadian	Doctoral Research Fellow	Biosciences	AQUA
Ane	Haarr	Norwegian	Doctoral Research Fellow	Biosciences	AQUA
Alexander	Håland	Norwegian	Doctoral Research Fellow	Chemistry	SMV
Thea	Hatlen Heimdal	Norwegian	Postdoc	Geosciences	CEED
Eddy Walther	Hansen	Norwegian	Professor	Chemistry	SMV
Havard	Kauserud	Norwegian	Professor	Biosciences	EVOGENE
Heidi	Konestabo	Norwegian	Researcher	Biosciences	AQUA/Science Library
Havard	Kristiansen	Norwegian	Doctoral Research Fellow	Geosciences	GeoHyd
Kirstin	Kruger	Norwegian	Professor	Geosciences	MetOs
Jinxing	Li	Chinese	Visiting scientist	Chemistry	SMV
Claus Jørgen	Nielsen	NA	Professor	Chemistry	SMV

POSTDOCS, RESEARCHERS AND ASSOCIATES

First name	Last name	Nationality	Position	Institute	Section
Maja	Nipen	Norwegian	Doctoral Research Fellow	Chemistry	SMV
Jon Petter	Omtvedt	Norwegian	Professor	Chemistry	SMV
Nicolas	Valiente Parra	Spanish	Postdoc	Biosciences	AQUA
Elin	Ristorp Aas	Norwegian	Doctoral Research Fellow	Geosciences	MetOs
Sabrina	Schultze	German	Doctoral Research Fellow	Biosciences	AQUA
Kamran	Shalchian-Tabrizi	Norwegian	Professor	Biosciences	EVOGENE
Trude	Storelvmo	Norwegian	Associate Professor	Geosciences	MetOs
You-Ren	Wang	Taiwanese	Postdoc	Biosciences	AQUA
Jing	Wei	Chinese	Doctoral Research Fellow	Biosciences	AQUA

ADMINISTRATIVE AND TECHNICAL STAFF

First name	Last name	Nationality	Position	Institute	Section
William	Hagopian	American	Senior Engineer	Geosciences	CEED
Jan	Heuschele	German	Senior Advisor	Biosciences	AQUA
Kari	Keveseth	Norwegian	Senior Executive Officer	Chemistry	SMV
Eline	Mosleth Færgestad	Norwegian	Engineer	Chemistry	SMV



The participants of the kick off meeting in Drøbak 2019

COURSES AT CBA

covering CBA's topics and taught by our researchers

Name	ID	Topics
Environmental and climate challenges	KJM1700	The course provides a basic scientific introduction to the environmental challenges and several of the UN's sustainability goals, and how environmental authorities use scientific insights.
Biogeochemistry	BIOS3070/ KJM3070	The course focuses on couplings between biological, geological and chemical processes, on the interactions between climate and the environment, and human impacts on these processes.
Contaminants in the geoenvironment	GEO4161	Contaminants in soils and ground water pose a threat to our society and the limited land and water resources. The course covers a range of topics from types of contaminants, over the physical and chemical distribution among phases/media to biogeochemical processes in soils and groundwater.
General Toxicology	BIOS4500	The course will cover basic toxicology and ecotoxicology, including how toxic substances are taken up in the organisms, distributed, bio-transformed and excreted, how toxic substances react with biomolecules and downstream consequences for the organism, as well as knowledge about toxic substances, e.g. metals, organic contaminants and pesticides.
Environmental Chemistry II	KJM5700	The course provides an integrated description of the chemical processes and equilibrium systems that determine mobility, transport, turnover and effects of chemical contaminants in air, soil and water. It also provides an introduction to natural chemical processes in the environment.
Chemical processes in soil and ground water	GEO5900	The course covers the main geochemical reactions controlling the chemical composition of soil and ground water, and how these can be quantified and used in interpreting different processes effecting the water quality.
Toxicants in ecosystems and humans: effects	BIOS5411	This course gives insight into how toxicants affects humans and the environment, with a particular focus on individual effects. Toxicants affect many of the same processes in different organisms and the course will discuss similarities and differences between different species, using mammalian toxicology as a starting point. The course includes aspects of both ecotoxicology and human toxicology.
Toxicants in Ecosystems and Humans: Exposure and Accumulation	BIOS5412	The course gives insight into how toxicants are distributed in the environment and accumulated by humans and other organisms. The focus is on important mechanisms and processes affecting the distribution and accumulation of toxicants and the interaction with other stressors, physiological and ecological adaptations, life history traits and the phylogenetic history of the organism.

Centre for Biogeochemistry in the Anthropocene

The Faculty of Mathematics and Natural Sciences

University of Oslo

P.O.Box 1066 Blindern

NO-0316 Oslo, Norway

www.mn.uio.no/cba