

## 1.006 Intrinsic chemical reaction between iron oxide and iodide in ice and its environmental impacts.

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Abstract:

It is known that the chemical processes taking place in ice phase is different from that in aqueous water. This difference between two phases might control the mobility, bioavailability, toxicity, and the environmental fate of organic and inorganic species. In general, most chemical reactions slow down as the reaction temperature decreases. However, various redox chemical processes are accelerated when the solution is solidified. Iron(Fe) is one of the most important trace elements for living species and the limiting component to control primary production in HNLC(High Nutrient and Low chlorophyll) regions including Southern Ocean. Consequently, this stimulated primary production by bioavailable iron can absorb atmospheric CO<sub>2</sub> and then affect climate change. Most of the iron in environment is existed as iron oxide or (oxy)hydroxides form and they are not directly bioavailable for living organisms. Dissolution of iron oxides increases their bioavailability. The chemical fate of active halogen compounds in the polar atmosphere controls ozone and mercury depletion events, oxidizing capacity, and dimethyl sulfide(DMS) oxidation to form CCN(cloud-condensation nuclei). The sources and mechanisms of iodine species in polar atmosphere are not well understood compared to those of chlorine and bromine. In this work, we studied the reductive dissolution of iron oxide particles to produce bio-available Fe(II)<sub>aq</sub> and simultaneous oxidation of I<sup>-</sup> (iodide) to produce I<sub>3</sub><sup>-</sup> (tri-iodide) in ice phase under UV irradiation or dark condition. The reductive dissolution of iron oxide and oxidation of iodide was markedly enhanced in ice phase regardless of presence or absence of light. The detailed experimental conditions and mechanism will be discussed in the presentation.

## **1.007 125,000 year bromine variability in connection to Arctic sea ice in the Renland ice core.**

Early Career Scientist

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Abstract:

Sea ice is a crucial parameter in the climate system. Both seasonal and multiyear Arctic sea ice have suffered a consistent area reduction of since the 1980s-satellite era. In the framework of a warming climate and a sea ice decline, the reconstruction of sea ice is of crucial importance to predict its future trend.

Bromine and sodium are present in sea salt aerosol and several condensed saline phases on sea ice surfaces.

Bromine plays a central role in the sea ice chemistry in the polar boundary layer through recycling multiphase

reaction over sea salt aerosol and fresh sea ice surfaces that lead to exponential release of gas phase bromine

during springtime. Therefore, bromine enrichment in snow, with respect to sodium in seawater, has been linked to

first year sea ice variability in the Arctic and Antarctica.

We present here bromine enrichment variability driven by Arctic sea ice, from measurements in the Renland ice

core (71.3°N 26.5°W, East Greenland). The core provides a detailed record of the Holocene, extending back to

the last interglacial period, the Eemian. Directly facing the East coasts of Greenland, the bromine enrichment

record in Renland might allow the first glacial-interglacial reconstruction of sea ice in this sector.

## 1.008 The International Global Atmospheric Chemistry (IGAC) Project.

Presenting Author:

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Abstract:

The atmosphere is the integrator of the Earth system. Human emissions of pollutants and long-lived greenhouse gases into the atmosphere have caused dramatic transformations of the planet, altering air quality, climate and nutrient flows in every ecosystem. Understanding the global atmosphere requires an international network of scientists to address these issues. Acknowledgement of this need led to the formation of IGAC in 1990.

IGAC facilitates atmospheric chemistry research towards a sustainable world by fostering community, building capacity, and providing leadership.

- **Fostering Community:** IGAC is an open international community of atmospheric scientists actively collaborating across geographical boundaries and disciplines in order to contribute to addressing the most pressing global change and sustainability issues through scientific research. The IGAC biennial science conference and the facilitation of numerous thematic workshop every year provides opportunities to build cooperation and disseminate scientific information across IGAC international community.
- **Building Capacity:** IGAC builds scientific capacity through its early career program and national and regional working groups. The IGAC early career program allows scientists to join an international network early in their career. The IGAC national and regional working groups create a strong cohesive community of atmospheric scientists in emerging countries/regions.
- **Providing Leadership:** IGAC provides intellectual leadership by identifying and fostering activities on current and future areas within atmospheric chemistry research that link emissions, atmospheric processes and atmospheric composition to global change and sustainability issues such as human health, climate, ecosystem and how individual and societal responses feedback onto the core research-led foci of IGAC.

## **1.009 An Overview of the Roland von Glasow Air-Sea-Ice Chamber: Bringing the Arctic to the Laboratory.**

Presenting Author:

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Abstract:

The facility was the brainchild of the late Prof. Roland von Glasow and is being continued to be developed with the aim of creating a world class robust and versatile facility. The high costs and problems of reproducibility when conducting Arctic field work led to the design of a coupled Ocean-Sea-ice-Atmosphere chamber, designed to "bring the Arctic to the laboratory". The facility is a highly instrumented chamber capable of growing first-year sea-ice up to thicknesses of ~25cm with a focus on in-situ real-time data which can be viewed and analysed mid-experiment. The "ocean" is equipped with up to three salinity and temperature probes, user controlled circulation and the ocean heat flux is controlled through heating pads at the base of the chamber. The sea-ice is monitored with a range of high (1cm depth interval) resolution instruments gathering continuous information on sea-ice temperature, resistivity and pressure. Fibre optic probes can be deployed to monitor the light field within the ice for UV-Vis wavelengths. Above the ice, the atmosphere can be contained in a PTFE-FEP enclosure with sampling ports allowing measurement of gases such as CO<sub>2</sub>, CH<sub>4</sub>, O<sub>3</sub> and NO<sub>x</sub> along with spectral radiation and temperature. Above the atmosphere is a UVB-UVA-Visible lighting rig with spectral range from 280nm to 750nm.

Here, we present a brief overview of the facility, proof of concept experiments that have been undertaken already, and the future outlook for the facility. The facility currently has Trans-national access funds available to support non-UK science collaboration with proposals for new experiments and scientific partnerships very welcome.

## 1.010 Hunting liquid micro-pockets and quasi-liquid layers of ice in presence of salt or acidic trace gases :: X-ray spectroscopy.

Presenting Author:

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Abstract:

A crucial factor determining the overall reactivity in the cryosphere and ice clouds is the local physical environment of reactants: The reactivity decreases significantly upon crystallization. Surprisingly, the phases of NaCl-ice systems are still under debate. In the present study, we present new data from a method sensitive to small changes in the local hydrogen-bonding network surrounding the chlorine ions. The study indicates significant differences in the phases of NaCl - water mixtures for the surface of the ice vs. its bulk. This finding further contrasts some earlier observations, where the presence of liquid below the eutectic point of bulk solutions was postulated. This has significant impact on modelling chemical reactions in snow or ice and its environmental consequences. At temperatures where melt is absent, it has been shown that dopants can lead to an increased disorder in the structure at the air-ice interface and that this disordered region represents a reservoir to which large amounts of trace gases can be dissolved and in which chemistry is rapidly occurring. Here, I briefly show results demonstrating the ability of core-electron spectroscopy to also probe the pre-melting of ice in presence of HCl and of formic acid. The results support a more complex picture of the interaction of dopants with ice, where a liquid-like hydration shell is formed in their vicinity. At low concentration this may not necessarily lead to a widespread disorder of the whole ice surface. The impact of this locally constrained disorder on the chemical reactivity is essentially open. Overall, these studies demonstrate our ability to probe the liquid and quasi-liquid content of ice right at the local environment of chemical reactants. Consequences for chemical reactivity are discussed for the heterogeneous reaction of ozone with bromide.

## 1.014 Evidence for marine-biogenic influence on summertime Arctic aerosol.

Early Career Scientist

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Abstract:

We present vertically-resolved measurements of aerosol composition made during a period of strong regional influence in the Canadian High Arctic. This period was characterized by stable and clean atmospheric conditions, with low wind speeds, and low carbon monoxide and black carbon concentrations. Under these conditions, we observed organic aerosol (OA)-to-sulfate ratios that peaked at an average of 2 near the surface. Methanesulfonic acid (MSA)-to-sulfate ratios also peaked nearest to the surface, with an average of 0.10, indicating a contribution from ocean-derived biogenic sulphur. Both the MSA-to-sulfate and OA-to-sulfate ratios were significantly ( $p < 0.001$ ) correlated with a measure of the air mass residence time over open water derived from the model FLEXPART-WRF. This marine-influenced OA was less oxygenated than OA observed at other times and at higher altitudes, suggesting that it had undergone less atmospheric ageing. Cloud condensation nuclei concentrations (measured at 0.6% supersaturation) were remarkably constant near  $120 \text{ cm}^{-3}$  when the fraction of OA was less than  $\sim 60\%$ , but increased to as high as  $350 \text{ cm}^{-3}$  when the organic fraction was larger and with longer air mass residence times over open water. Our observations provide new insight into the vertical distribution of aerosol composition in the summertime Arctic, and

illustrate the importance of marine-influenced organic aerosol in this remote environment.

## **1.018 Bringing BEPSII to CATCH.**

Presenting Author:

**James Lawrence France**, School of Environmental Science, University of East Anglia, Norwich, UK, [j.france@uea.ac.uk](mailto:j.france@uea.ac.uk)

Abstract:

The BEPSII (Biogeochemical exchange processes at Sea Ice Interfaces) SCOR working group has some overlap with CATCH in scope and participants. Here we present an update on the progress that BEPSII has made, upcoming work such as the Essential Climate Variables in sea ice (ECVice) and a very brief review of the April 2017 BEPSII San Diego meeting that may interest the CATCH community. It is hoped that by bringing the most relevant parts of BEPSII to CATCH (and visa-versa) that further integration of the communities can occur where beneficial and scope for potential further collaboration can be identified.



## 1.019 Halogen activation over snow and ice doped with NaBr aerosols.

Early Career Scientist

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Abstract:

Snow and ice are actively involved in the exchange and transport of compounds between spheres in the environment. It is now common knowledge that ice and snow are also active players in the chemistry of the environment. An important process in the cryosphere-atmosphere interaction is halogen activation. While snow and ice are not prerequisites for this process, they have particularly important roles especially in the stratosphere and in polar areas. Snow provides the high surface area needed for heterogeneous reactions while freezing sea-ice provides a pre-concentration of sea-salt for the propagation of halogen activation. In addition to snow and ice, the role of aerosols in halogen activation is also of recent interest. Sea-salt aerosols can be scavenged by falling and blowing snow as well as surface snow. Therefore, in this study, we aim to combine snow and ice, and aerosols to study the impact of this mixed system on halogen activation. In the snow system, we aim to investigate the impact of metamorphism of snow on the observed chemistry from aerosol doped snow. This involves collaboration with snow physicists to develop environmentally realistic snow samples for kinetic studies. In the ice system, we will investigate ozone loss over aerosol deposited on an ice film using coated wall flow tubes. This combined study will provide insight into chemistry in snow as well as inform snow contribution to halogen activation in the atmosphere. A collaboration involving a "lab in the field" study with measurements of aerosol composition, and correlations with observed ozone depletion/halogen activation over collected fresh snow may be able to link this laboratory work with field observations.

## 1.020 Polar boundary layer bromine explosions and ozone depletion in the global chemistry climate model EMAC.

Presenting Author:

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Abstract:

We have recently implemented a treatment of bromine release and recycling on sea ice and snow covered surfaces in the global chemistry climate model EMAC (ECHAM5-MESSy Atmospheric Chemistry model), based on the scheme of Toyota et al. (2011). In this scheme, dry deposition fluxes of HBr, HOBr, BrNO<sub>3</sub>, and O<sub>3</sub> over ice and snow covered surfaces are converted back into Br<sub>2</sub> fluxes. Many aspects of observed bromine enhancements (so called bromine explosions) and associated episodes of near-complete depletion of boundary layer ozone, both in the Arctic and in the Antarctic, are reproduced by this relatively simple approach. We will present first results from our model studies, including comparisons with satellite BrO column and surface ozone observations. However, the implemented scheme still relies on a number of assumptions and clearly offers the potential for further refinement. Progress in global modelling of bromine release/activation on snow and sea ice would benefit from a close collaboration between field observations, process studies and different modelling groups. At the same time global models can help to put results from individual studies into a wider perspective and may be used to investigate the wider impact of different mechanisms.

## **1.021 The Arctic hydrosphere-cryosphere complex: a dynamic nexus of biogenic dimethylsulfide production during summer.**

Presenting Author:

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Abstract:

Sea-ice dynamics exert a strong influence on arctic microbial communities and their production and emission of the climate-active gas dimethylsulfide (DMS) in the Arctic. High-frequency measurements made in summer 2016 using a novel automated instrument (ACT-MIMS) during a 6-week oceanographic campaign in the Canadian Arctic Archipelago corroborate the hypothesis suggesting that the Arctic Ocean is a nexus of biogenic DMS production associated, in part, with diversified niches linked with dynamic sea-ice during the productive season. Results reveal that microbial communities thriving in marginal ice zones contribute significantly to reservoirs of DMS. Furthermore, waters underlying sea-ice are as rich in DMS as their ice-free counterparts suggesting potentially important pulsed effluxes of DMS during ice break-up and the establishment of leads and cracks. Brackish melt ponds harbor DMS-producing communities and thus represent an additional source of DMS in direct contact with the atmosphere. The anticipated proliferation of arctic melt ponds may play a relevant role in spring-summer dynamics of DMS in the future and warmer Arctic. An unexpected outcome of the 2016 campaign was the detection of high DMS under a giant decaying ice floe, a difficult medium to sample from traditional ice camps in view of its high instability. Preliminary results suggest that strong haline stratification under melting floes may result in the entrapment of microbial communities within highly irradiated under-ice waters and a resulting up-regulation of photo-protective mechanisms including DMS production. Large variability in DMS and strong near-surface DMS gradients were detected across hydrographic fronts and transitional areas between open water and oceanic inlets and fjords. Near-terrestrial sources of DMS had never been surveyed at such fine scale thus far in the Canadian Arctic Archipelago and the high concentrations measured (up to  $30 \text{ nmol L}^{-1}$ ) warrant further investigation and monitoring of these regions as significant emitters of DMS during summer.

## 1.024 Sensitivity of Arctic mixed-phase clouds to micro- and macrophysical changes.

Early Career Scientist

Presenting Author:

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Abstract:

Due to global warming, the Arctic climate is rapidly changing. Sea ice melt will lead to more open ocean with associated local changes in surface fluxes, which may drive additional changes in aerosol concentration. Moreover, a sea ice free Arctic will also lead to enhanced shipping across the Arctic basin, increasing the aerosol input from ship exhaust emissions or other anthropogenic sources. The combined effects of these factors on Arctic low cloud cover remain to be explored. Low-level boundary layer clouds such as mixed-phase clouds (MPCs) are common in the Arctic and play a key role in determining the radiative balance. Any radiative impact from clouds may further enhance or buffer the ongoing Arctic warming.

We investigate processes that impact the properties of MPCs and determine their contribution to the Arctic energy budget. The impact of high and low cloud condensation nuclei (CCN) concentrations on boundary clouds is tested as well as the impact of sea ice loss and variable boundary fluxes. In order to evaluate the influence of the large-scale forcing compared to microphysical changes and surface fluxes, we will also investigate the importance of different synoptic situations. Addressing these effects on MPCs, we conduct a series of kilometer-scale and cloud-resolving large eddy simulations (LES), exploring these sensitivities in close proximity to available observations.

However, to allow for realistic model simulations, there is a need for more detailed observations on Arctic dynamic forcing, aerosol composition, CCN, and ice nucleating particles (INP). Since CCN and INP can be of chemical or biological origin, interdisciplinary collaboration is required to collect appropriate measurements. Especially for the ice phase, the paucity of observations hinders a realistic representation of ice processes in models. Moreover, the challenge of performing research and collecting observations in remote Arctic terrain calls for close international cooperations.

## 1.025 In situ real-time measurements of key trace gases in ice-core and oceans.

Presenting Author:

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Abstract:

A general overview of the potential of new technology for in-situ real time measurement of air bubble in ice-core and dissolved gases in the oceans will be presented here, opening the doors to new interdisciplinary collaborations and further discussions about new strategies for studying the exchanges between atmosphere, cryosphere and oceans. In the frame of a challenging ice-core drilling project "SUBGLACIOR", we are today developing an unique probe for finding ice older than 1Myrs in Antarctica. The probe consists of an embedded optical spectrometer capable to measure in situ and real-time the composition of the air bubbles trapped in the ice ( $\text{CH}_4$  and  $\delta\text{D}$  of  $\text{H}_2\text{O}$ ). A first test campaign has been carried out during the last austral summer, and a future test campaign followed by a final campaign looking for the "Oldest Ice" will be carried out in the following years.

In 2014, while looking for a more accessible environment for testing the drilling probe, the Mediterranean Sea was selected. This test campaign highlighted high potential for monitoring marine environments. Advantages of our technology are: fast response time (~15sec), high dynamic range, multiple species detection and access to isotopic signatures, telemetric deep sea applications with compatibility for Unmanned Underwater Vehicles (UUVs) surveys.

In October 2015, in the framework of the CAGE project, the 'SubOcean' instrument has been deployed for measuring dissolved  $\text{CH}_4$  over a gas-hydrate zone of western Svalbard. Continuous measurements to depths up to 400m were made over three days, resulting in high-resolution 3D profiles (~100k data points in 30 hours, 16  $\text{km}^2$  of surface covered). The very fast response time of the sensor allows to display the in situ measurements in real-time directly onboard of the ship while underway. Today, we are already working on a new generation of spectrometers which access isotope signatures.

## 1.026 Black Carbon and Aerosol Chemistry at high-altitude site in the central Himalayas.

Presenting Author:

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Abstract:

Black carbon (BC), derived from variety of anthropogenic emission sources, have a direct effect on regional air-quality, hydrological cycle and climate. The pristine regions like Himalaya and Arctic are also influenced by the long-range transport of atmospheric aerosols. Our studies conducted during 2005-2008 suggest that BC concentration varies between 0.14 to 7.6  $\mu\text{gCm}^{-3}$  (range: 0.1% in summer to 7.6% of total suspended particulates matter in winter) and has a large positive atmospheric radiative forcing ( $\sim +28 \pm 5 \text{ Wm}^{-2}$ ) and high values of heating rate ( $0.80 \pm 0.14 \text{ Kday}^{-1}$ ) at Manora Peak in the central Himalaya. Aerosol optical depth (AOD) values exhibit significant variability, as high as 0.45, with higher AOD values in summer mainly due to an increase in mineral dust contribution. Our recent study on rain water chemistry reveal a significant contribution of crustal and anthropogenic sources in the rain water and neutralization processes in the central Himalaya. In contrast, single scattering albedo (SSA) varied from 0.74 to 0.88 with relatively lower SSA values during summer, suggesting an increase in absorbing BC and mineral dust aerosols. The radiative forcing of BC aerosols and changes in snow-albedo strongly depends on ambient BC concentration and amount of BC deposited on to snow surfaces which may subsequently enhance melting of the glaciers in the Himalaya. I wish to discuss results obtained on chemical composition of rain-water, aerosols and optical properties (absorption coefficient, single scattering albedo, SSA and AOD) from a high-altitude site (Manora Peak) in the central Himalaya.

## 1.027 CATCH activities at British Antarctic Survey field research platforms?.

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Abstract:

The British Antarctic Survey (BAS) has a recognised history of successfully supporting field programmes in the polar regions. Moreover, BAS scientists have proven track records researching facets of the polar environment (ocean, ice, snow, biology, clouds) as well as their interactions.

The above research has been enabled by scientific capability across a range of platforms. For example, the Clean Air Sector Laboratory, at Halley station on Antarctica's Brunt Ice Shelf, is ideally placed for studying air/snow/ice exchange mechanisms as well as Southern Ocean processes. The CASLab is influenced by air masses from the sea ice zone, as well as inland Antarctica and the Southern Ocean. It has hosted a number of international and multi-seasonal measurement campaigns, in particular enhancing our understanding of halogen and nitrogen cycling. The Rothera Time Series (RaTS), at Rothera station on the West Antarctic Peninsula (WAP), was established in 1997, motivated by the need to understand ocean-atmosphere-ice feedbacks in regions of rapid change. It comprises year-round profiling of physical properties (temperature, salinity, density) of the water column, plus sampling for a range of biogeochemical and biological parameters. The BAS Twin Otter, MASIN, is adapted for measurements of atmospheric physics and chemistry. It has been used extensively to observe cloud properties, both within clouds and the environment around the clouds, as well as for measurements of fluxes over sea ice. Finally, the UK's new polar research vessel, Sir David Attenborough, will be launched in 2019, and provide state-of-the-art facilities for measurements in the sea ice zone & open ocean.

This presentation will introduce these research platforms, and explain how they could contribute to CATCH-type research activities.

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<https://www.bas.ac.uk/polar-operations/sites-and-facilities/facility/halley/clean-air-sector-laboratory-caslab/>

<https://www.bas.ac.uk/project/rats/>

<https://www.bas.ac.uk/polar-operations/sites-and-facilities/facility/airborne-science-and-technology/twin-otter-meteorological-airborne-science-instrumentation-masin/>

<https://www.bas.ac.uk/polar-operations/sites-and-facilities/facility/rrs-sir-david-attenborough/>

## 1.028 Heterogeneous Oxidations of Oxy-PAHs in the Environment..

Presenting Author:

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Abstract:

Heterogeneous reactions occurring at interfaces (i.e., the air/water and air/ice interfaces) may proceed with different rates and mechanisms from those typical of reactions in the gas-phase and (bulk) water or ice. This laboratory work exploring reactions at the air/water interface will discuss: (1) the heterogeneous oxidation of iodide at the interface of aqueous microdroplets with global implications to the loss of ozone, and (2) the competitive loss of biomass burning probes by OH-initiated *versus* direct ozonolysis reactions. The experimental results show how the fast oxidation of iodide ( $I^-$ ) by 50 ppbv  $O_3$  at the air-water interface of microdroplets produces hypoiodous acid (HIO), iodite ( $IO_2^-$ ), iodate ( $IO_3^-$ ), triiodide ( $I_3^-$ ), and molecular iodine ( $I_2$ ). A 28 % enhancement in the uptake of  $O_3(g)$  is observed at the air-water interface for increasing concentration of alkali halide salt from 10 nM to 100  $\mu$ M. The second part of the talk will explain how the attack of OH radicals on aromatic hydrocarbons emitted during combustion and biomass burning produces polyhydroxylated aromatics, and chromophoric quinones and C-C coupling products. A different degradation pathway exists at the air-water interface, where oxo- and di-carboxylic acids of low molecular weight (LMW) are formed by direct ozonolysis of poly-hydroxylated aromatic compounds. Mass spectrometry measurements confirm secondary processing showing the production of LMW carboxylic acids found in aqueous secondary organic aerosol (AqSOA). Overall, this transformative work should propel new collaborations that will benefit both experimental and modeling atmospheric researchers. For example, these international collaborations will aim 1) to explain, e.g., how the produced HIO and  $I_2$  can be transferred to the gas-phase and participate directly in the destruction of tropospheric ozone (e.g., over the open ocean or over the Arctic region), and 2) to initiate field work to quantify the contribution of proposed pathways for AqSOA formation.



## 1.029 Can we use field data and models to constrain laboratory measurements of nitrate photochemistry in/on ice?.

Presenting Author:

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Abstract:

Nitrate ( $\text{NO}_3^-$ ) in snow and ice is an important proxy for levels of nitrogen oxides ( $\text{NO}_x$ ) in past atmospheres. Nitrate also undergoes direct photodegradation to produce both  $\text{NO}_x$  and nitrite/nitrous acid ( $\text{NO}_2^-$  and HONO), which are important to atmospheric chemistry. While nitrate photolysis in/on ice has been studied in the lab (and field) for almost 20 years, there is no consensus on the quantum yields for  $\text{NO}_2$  and HONO production.

Studies with  $\text{NO}_3^-$  present in liquid-like regions in ice indicate quantum yields are low and follow the same temperature behavior as in liquid, but other studies, including those with nitrate at the air-interface, indicate that quantum yields are much higher, in some cases by over a factor of 100.

Narrowing this enormous range in possible quantum yields from the lab might be possible using field observations in sunlit snow. However, this is complicated by a number of factors, including constraints on the transport of  $\text{NO}_x$  and HONO from the firm air to the atmosphere and confounding contributions from nitrate photolysis in particles. In this presentation I will discuss the general framework of how field measurements combined with modeling might help constrain nitrate quantum yields and how this could involve members of the CATCH community.

## 1.030 Evaporating brine from frost flowers with electron microscopy: implications for atmospheric chemistry and sea-salt aerosol formation.

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Abstract:

An environmental scanning electron microscope was used for the first time to obtain well-resolved images, in both temporal and spatial dimensions, of lab-prepared frost flowers (FFs) under evaporation within the chamber temperature range from  $-5^{\circ}\text{C}$  to  $-18^{\circ}\text{C}$  and pressures above 500 Pa. Our scanning shows temperature-dependent NaCl speciation: the brine covering the ice was observed at all conditions, whereas NaCl crystals were formed in the surface layer of FFs at temperatures below  $-10^{\circ}\text{C}$  as brine oversaturation was achieved. Finger-like ice structures covered by the brine, with a diameter of several micrometres and length of tens to one hundred micrometres, are exposed to the ambient air. The brine-covered fingers are highly flexible and cohesive. The exposure of the liquid brine on the micrometric fingers indicates a significant increase in the brine surface area compared to that of the flat ice surface at high temperatures, whereas the NaCl crystals can become sites of heterogeneous reactivity at lower temperatures. There is no evidence that, without external forces, salty FFs could automatically fall apart to create a number of sub-particles at the scale of micrometres as the exposed brine fingers seem cohesive and hard to break in the middle. The fingers tend to combine together to form large spheres and then join back to the mother body, eventually forming a large chunk of salt after complete dehydration.

This study is a good example of how fruitful it will be of collaboration across disciplines (and via international collaboration). For example, modellers raised question such as whether evaporating process of saline crystal sublimation could cause sea salt aerosol production, then scientists working in the lab saw very interesting phenomenon which has not been observed before.

## **1.032 Cross-polar transport and scavenging of Siberian aerosols containing black carbon during the 2012 ACCESS summer campaign.**

Presenting Author:

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**Hans Schlager**, DLR, Institut für Physik der Atmosphäre, Oberpfaffenhofen, Germany

Abstract:

During the ACCESS airborne campaign in July 2012, extensive boreal forest fires resulted in significant aerosol transport to the Arctic. A 10 day episode combining intense biomass burning over Siberia and low-pressure systems over the Arctic Ocean resulted in efficient transport of plumes containing black carbon (BC) towards the Arctic, mostly in the upper troposphere. A combination of in situ airborne observations, satellite analysis and WRF-Chem simulations are used to understand the vertical and horizontal transport mechanisms of BC with a focus on the role of wet removal.

During transport to the Arctic region, a large fraction of BC particles are scavenged by two wet deposition processes, namely wet removal by large-scale precipitation and removal in wet convective updrafts, with both processes contributing almost equally to the total accumulated deposition of BC. Our results underline that applying a finer horizontal resolution (40 vs 100km) improves the model performance, as it significantly

reduces the overestimation of BC levels observed at a coarser resolution in the mid-troposphere. According to the simulations at 40km, the transport efficiency of BC (TEBC) in biomass burning plumes is about 60%, which is impacted by small accumulated precipitation along trajectory (APT) (1mm). In contrast TEBC is very small (<30%) and APT is larger (5–10 mm) in plumes influenced by urban anthropogenic sources and flaring activities in Northern Russia, resulting in transport to lower altitudes.

TEBC due to grid scale precipitation is responsible for a sharp meridional gradient in the distribution of BC concentrations. Wet removal in subgrid parameterized clouds (cumuli) is the cause of modeled vertical gradient of TEBC , especially in the mid-latitudes, reflecting the distribution of convective precipitation, but is dominated in the Arctic region by the grid-scale wet removal associated with the formation of stratocumulus clouds in the PBL that produced frequent drizzle.

## 1.033 CATCH in the context of SOLAS.

Presenting Author:

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Co-Authors:

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Abstract:

The Surface Ocean-Lower Atmosphere Study (SOLAS) project was established in 2004 to provide international science coordination and capacity building between the biogeochemical-physical oceanic and atmospheric scientific communities. The new 2015-2025 SOLAS Science Plan scientific envelope comprises science disciplines ranging from air-sea interface and fluxes of mass and energy to the control ocean biogeochemistry exerts on atmospheric chemistry, from tropics to polar regions. The new SOLAS Science Plan also aims to further the understanding of interconnections between aerosols, clouds and marine ecosystems, as well as cross-cutting integrated topics such as polar oceans and sea ice. Within this context, the CATCH initiative focuses on atmospheric chemistry in the cold regions. This communication will highlight the synergies between both projects and the interfaces between CATCH and specific SOLAS scientific communities/themes.

## 1.034 The polar iodine paradox.

Presenting Author:

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Institute of Physical Chemistry Rocasolano, CSIC, Madrid, Spain., [a.saiz-lopez@ciac.jccm-csic.es](mailto:a.saiz-lopez@ciac.jccm-csic.es)

Abstract:

Iodine appears to be a dominant player in destroying ozone over coastal Antarctic sea ice while bromine's role is comparatively less. Conversely, bromine governs ozone destruction over Arctic sea ice while iodine has not been shown to significantly participate. In Antarctica ground- and satellite-based instruments have measured some of the highest levels of active atmospheric iodine seen anywhere on Earth. In contrast, only order of magnitude smaller amounts of active iodine were detected sporadically and localized in the sub-Arctic troposphere, but not directly over Arctic sea ice. This communication will explore the possible sources and causes of this uneven presence of iodine in the polar regions, which presents a scientific challenge connecting marine algae, ice and atmosphere.

## **1.036 Understanding the climate sensitivity of the snow source of reactive halogens.**

Presenting Author:

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Abstract:

The oxidation capacity of the atmosphere determines the lifetime of most reduced trace gases in the atmosphere. Reactive halogens have profound influences on the oxidation capacity of the atmosphere, and may have a high sensitivity to climate change due in part to their snow source. I will present new ice core evidence that suggests that reactive halogen abundance may have increased in colder climates, consistent with increases in snow and sea ice in the glacial world. A quantitative analysis of the magnitude of the change in reactive halogen abundances, sensitivity to climate, and examination of potential climate feedbacks requires large-scale model sensitivity studies. Inclusion of the snow and sea ice source of reactive halogens in large-scale models requires a model hierarchy that utilizes insights from laboratory studies for process scale models, and field campaigns to assess parameterizations in large-scale models. This collaboration across scales will enable future estimations of the impact of a changing cryosphere on the chemical composition of the atmosphere.

## 1.038 International Collaborations: The Arctic Council's Impacts on Background Concentrations of SLCF's in the Arctic.

Early Career Scientist

Presenting Author:

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Abstract:

Establishing and predicting the current and future background composition of trace gases and aerosols in the Arctic is imperative to understanding future climate change. The Arctic and the people who reside there are particularly vulnerable to changes in temperature, atmospheric composition, and sea ice extent. In an attempt to combat and adapt to Arctic climate change, the 8 nations that have territory in the Arctic circle formed the Arctic Council. Over the past two decades, the Arctic council has laid out a number of recommendations to reduce anthropogenic emissions in the region; recent recommendations have focused on the short-lived climate forcers (SLCFs) methane and black carbon (BC). However, while any reduction in SLCF emissions helps reduce future climate change, the impacts of the recommendations of the Arctic council have yet to be analyzed. This [poster/presentation] fills that knowledge gap by using the MIT IGSM framework to analyze the impacts that the (BC and CH<sub>4</sub>) mitigation recommendations of the Arctic Council would have on the region. In particular, the background concentrations of ozone, CO<sub>2</sub>, CH<sub>4</sub>, and black carbon (and associated temperatures and sea ice extents) in the Arctic are presented as functions of reductions in oil and gas emissions, vehicular and residential emissions, and landfill emissions.

The Arctic Council is an example of international cooperation and collaboration across geographical boundaries. However, many of the recommendations and questions identified by the Council require more than solely governmental cooperation on emission controls; scientific cooperation is also necessary to prioritize what governmental actions are necessary. This [poster/presentation] will also discuss the outstanding questions on SLCFs that the Arctic Council has identified and how the CATCH community can facilitate answering those questions.



## 1.039 Blowing snow-Aerosol Interactions: Composition Changes during Blowing Snow Events in Antarctica.

Early Career Scientist

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Abstract:

Snow-aerosol interactions (particularly due to lofted/blowing snow) is an important area of research, especially in polar regions. The current state of the science suggests that blowing snow is closely linked to aerosol generation and both physical and chemical processing. Unfortunately, few direct measurements of snow-aerosol interactions exist. The recent 2ODIAC campaign (2014/2015) deployed an online Aerosol Mass Spectrometer (AMS) capable of capturing single-particle mass spectra of aerosols in coastal Antarctica. This presentation will focus on these single particle results in the presence or absence of blowing snow. The discussion will focus on the mass spectral characteristics and organic components in the measured aerosols during blowing snow events via clustering analysis. Also discussed will be the effects that blowing snow has on the chemical and physical state of chloride in the aerosol. The effects of blowing snow on aerosol composition will also be tied to the number and size distribution information collected during 2ODIAC.

In addition to the aerosol-snow interactions results, the presentation will also discuss how the field of research practically requires international collaboration. The scope and magnitude of the questions raised by the data (e.g. what is the source of new particles during blowing snow events, are the enhancements in organics due to deposited aerosols, does mechanical interaction between snowflakes play a minor or major role, what is the role of gas-phase species and heterogeneous chemistry, etc.) can only be answered through measurements taken over long temporal scales, large spatial scales, and require expertise in multiple subjects. This breadth and depth of expertise and required equipment can only be answered through collaborations. We hope this initiates a broader dialogue to enable the type of collaboration within the atmosphere-cryosphere community necessary to examine the research questions surrounding blowing snow/aerosol interactions and other related areas.

## 1.040 Characterization of the chemical, physical and optical properties of atmospheric aerosols in the Canadian High Arctic .

Early Career Scientist

Presenting Author:

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Abstract:

Atmospheric aerosols, i.e. particulate matter (PM), are a major source of uncertainty in climate models. Due to this uncertainty, it is important to analyze quantitatively the correlation between the composition, the physical properties (e.g. particle size) and the optical properties of atmospheric aerosols. In the Arctic, climate change is much more rapid than the global mean, highlighting the important need for atmospheric measurements in this region. To this end, field measurements of atmospheric aerosols are currently being performed at the Polar Environment Atmospheric Research Laboratory (PEARL) in Eureka, Nunavut (80N, 86W) to characterize aerosols in the Canadian High Arctic. The surface instruments deployed include two PAXs (Photoacoustic Extinctionmeters) that measure aerosol light scattering and absorption at 870 nm and at 405 nm, an AMS (Aerosol Mass Spectrometer), an OPC (Optical Particle Counter) and a SMPS (Scanning Mobility Particle Sizer). Using the data obtained from these instruments, which have been operational since August 2015 until today, it is possible to observe changes in aerosol size distributions and aerosol concentrations as well as concomitant changes in the optical characteristics of aerosols.

In particular, the current aerosol measurements provide long-term observations of Arctic aerosol size distributions for both coarse and fine modes. Particles growth events were frequently observed during the summers of 2015 and 2016. In contrast, during the winter months long-range transport of pollution plumes to PEARL was observed. During these periods influenced by transported pollution, surface measurements of the aerosol scattering coefficient are compared against the coefficient values calculated using Mie theory and the measured aerosol size distribution with the goal of understanding the variability in aerosol optical properties.

## **1.041 sea ice-ocean-atmosphere biogeochemistry at ICM-CSIC.**

Presenting Author:

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Abstract:

Climate warming affects the development and distribution of sea ice, but at present the evidence of polar ecosystem feedbacks on climate through changes in the atmosphere is sparse. In this presentation, I will show main results carried out at the ICM-CSIC Barcelona (Spain) with interdisciplinary collaborations from UK, USA, Ireland, Spain, Sweden and Korea. Both Polar regions are considered. (1) By means of synergistic atmospheric and oceanic measurements in the Southern Ocean near Antarctica, we present evidence that the microbiota of sea ice and sea ice-influenced ocean are a previously unknown significant source of atmospheric organic nitrogen, including low molecular weight alkylamines. Given the keystone role of nitrogen compounds in aerosol formation, growth and neutralization, our findings call for greater diversity in modeling efforts linking the marine ecosystem to aerosol-mediated climate effects in the Southern Ocean. (2) Atmospheric new particle formation and growth significantly influences climate by supplying new seeds for cloud condensation and brightness. Currently, there is a lack of understanding of whether and how marine biota emissions affect aerosol-cloud-climate interactions in the Arctic. Here, the aerosol population was categorised via cluster analysis of aerosol size distributions taken at Mt Zeppelin (Svalbard) during a 11 year record. The daily temporal occurrence of nucleation events in the polar marine boundary layer was quantified annually as 18%, with a peak of 51% during summer months. Air mass trajectory analysis and atmospheric nitrogen and sulphur tracers link these frequent nucleation events to biogenic precursors released by open water and melting sea ice regions. The occurrence of such events across a full decade was anti-correlated with sea ice extent. We aim to present possible collaborations on sea ice-ocean-atmosphere biogeochemistry.

## 1.042 Speciation and location of impurities on ice characterized via spectroscopy and microscopy.

Presenting Author:

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**Xin Yang**, British Antarctic Survey, Natural Environment Research Council, Cambridge, UK

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Abstract:

We use absorption and emission spectroscopy in the UV-vis region together with probe molecules and environmental scanning electron microscopy (ESEM) to characterize interactions between impurities and ice. A reliable method to determine the acidity of frozen aqueous solutions<sup>1</sup> that correlates well with the observed reactivity was established.<sup>2,3</sup> Spectroscopic investigations of aromatic compounds suggest that the sample preparation (vapor deposition, rate of freezing) plays a decisive role in the speciation of compounds.<sup>4-6</sup> The ESEM of icy samples provides information of salt brine location and allows for observing metamorphoses with consequences for the formation of environmental aerosols.<sup>7,8</sup> We demonstrate the fruitfulness of international and interdisciplinary collaborations<sup>2,7</sup> and wish to continue these into future research. In particular, we are proposing the use of the ESEM for environmental ices and intend to contribute to the resolution of open questions where results from various laboratories do not exhibit coherence.

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## **1.043 air Pollution in the Arctic: Climate Environment and Societies (PACES).**

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Abstract:

Air pollutants in the Arctic have impacts on climate change, ecosystems, regional air quality, and human health. They include aerosol particles such as black carbon and trace gases such as tropospheric ozone. Atmospheric pollution contributes to Arctic environmental change, but Arctic change also has implications for atmospheric pollution. Rapid changes to and complex interactions within the Arctic environment due to global warming and socio-economic drivers mean that there is an urgent requirement to improve understanding of sources and impacts of Arctic air pollutants. Here, we review recent findings related to impacts of air pollution on Arctic climate, in light of a changing balance between Northern Hemisphere mid-latitude pollution sources and sources within the Arctic. We highlight that there are still major deficiencies in predictive capability and, in particular, knowledge about pollutant processing and loss during transport to the Arctic. We outline a strategy for reducing uncertainties through a combined measurements-modelling initiative focusing on the transport of Asian pollution to the Arctic. We also review our knowledge related to air pollution impacts on marine and terrestrial ecosystems as well as potential impacts of air pollutants on human health and highlight areas where our knowledge is still lacking. In particular, we examine the potential impacts of pollutants from local Arctic sources (e.g. oil/gas extraction, mineral extraction), which are poorly quantified, particularly in certain regions such as Siberia. We outline possible approaches to tackle these issues, such as community-based monitoring, which could be developed in collaboration with local Arctic societies to provide much needed information about pollution levels. The work presented here is being developed as part of the international IGAC (International Global Atmospheric Chemistry/ International Arctic Science Committee (IASC/Atmosphere WG) PACES initiative - (see [www.igacprojects.org/PACES](http://www.igacprojects.org/PACES)). We will also explore synergies with the CATCH initiative.

## **1.044 SIMULTANEOUS OBSERVATION OF PRECURSOR VAPOURS, CLUSTERS AND NEW PARTICLE FORMATION IN ANTARCTICA.**

Early Career Scientist

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**Mikko Sipilä**, University of Helsinki

Abstract:

An aerosol and aerosol precursor vapours measuring campaign was conducted during the summer of 2014 – 2015 in the Finnish Antarctic research station Aboa; located in Queen Maud's Land, Antarctica (73°03'S, 13°25'W). This is the first time when simultaneous measurements of aerosol forming precursor vapours, molecular clusters and aerosol size distribution have been measured during rare Antarctic new particle formation events.

The measurement campaign was done from the end of November 2014 to the early February 2015. An unforeseen arsenal of instruments were brought to Aboa, including two Particle Size Magnifier (PSM) to detect the smallest particles in 1-3 nm size range, Neutral Air Ion Spectrometer (NAIS) for size distribution measurements of both ions and neutral particles and a Differential Mobility Particle Sizer (DMPS) for larger particles. Simultaneous use of these instruments covered a large size range from 1-800 nm and provided comprehensive picture of the aerosol size distribution in the pristine air of Antarctica. Two time-of-flight mass spectrometers (API-TOF and CI-API-TOF) were analysing the precursor vapour concentration and ion clusters during the campaign. New particle formation (NPF) days were detected around midsummer when biological activity of the surrounding ocean and melt water ponds are most active. Sulphuric acid (SA), methanesulfonic acid (MSA) and iodic acid (HIO<sub>3</sub>) were detected during the summer and NPF was studied both the ion and neutral pathways. Trajectories of the air masses for 48 h prior their arrival to Aboa were calculated and they demonstrated clear contribution of marine environment to the observed NPF event, supported by the detection of MSA and sulphuric acid.

## **1.045 Release of photochemical bromine from blowing snow events in high latitudes.**

Presenting Author:

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**John Pyle**, NCAS Climate and Centre for Atmospheric Science, Cambridge University

Abstract:

In the last two decades, significant depletion of boundary layer ozone (ozone depletion events, ODEs) has been observed in both Arctic and Antarctic spring. ODEs are attributed to catalytic destruction by bromine radicals (Br plus BrO), especially during bromine explosion events (BEs), when high concentrations of BrO periodically occur. The source of bromine and the mechanism that sustains the high BrO levels are still the subject of study. Recent work by Pratt et al. (2013) posits Br<sub>2</sub> production within saline snow and sea ice, which leads to sudden ODEs. Alternatively, sea salt aerosol could act as a source of bromine via chemical reaction leading to halogen displacement, and could recycle Br, sustaining BrO plumes.

In light of these facts, Yang et al. (2008) suggested snow could provide a source of (depleted) sea-salt aerosol if wicked from the surface of ice. They suggest that rapid depletion of bromide via acid displacement from the aerosol will constitute a source of photochemical Br<sub>y</sub>. Given the large sea ice extent in polar regions, this may constitute a significant source of gas phase bromine in the polar lower atmosphere. While bromine release from blowing snow is perhaps less likely to trigger sudden ODEs, it may make a contribution to regional scale processes affecting ozone levels.

Currently, the model parameterization of Yang et al. assumes that rapid release of bromine occurs from fresh snow on sea ice during periods of strong wind. The parameterization depends on an assumed sea-salt aerosol distribution generated via sublimation of the snow above the boundary layer, as well as taking into account the salinity of the snow.

We are interested to work with researchers across disciplines interested in halogens and to address questions of mutual interest on e.g. ozone depletion near surface, bromine budgets and impacts on regional ozone.



## **1.046 Arctic aerosol measurements and transport in the frame of the Ice-Atmosphere-Ocean Observing System (IAOOS) project.**

Presenting Author:

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**Jennie Thomas**, LATMOS, UPMC-CNRS-UVSQ, Paris and Guyancourt, France

Abstract:

A new observational network is being developed for ocean-ice-atmosphere climate survey over the Arctic Ocean, in the frame of the French IAOOS Equipex project, to better understand the role of aerosols and clouds in the Arctic. Automated backscatter microlidar measurements have allowed to profile aerosols and clouds in the low and mid-troposphere during first campaigns, and to retrieve aerosol optical properties in complement to CALIPSO and IASI observations. Measurements taken end during spring 2014 close to the North Pole and end of winter 2015 north of Svalbard show large occurrence of aerosol and haze layers both from ground and space observations. Analysis of trajectories have been done to link more closely both observations types and better identify aerosol sources. Observations are presented and first results are discussed.

## 1.047 The Problem with Arctic Clouds.

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Abstract:

Modelling studies have suggested that the Arctic cloud response (including the indirect aerosol effect) to sea-ice retreat may mitigate the ice-albedo climate feedback. However, the response of Arctic clouds to increasing temperatures and ice loss is uncertain. This uncertainty derives from multiple factors, most significantly, from our lack of understanding of the source of high-latitude cloud condensation nuclei (to which Arctic clouds are peculiarly sensitive). Observations suggest a combination of primary and secondary sources ranging from ammonia induced nucleation of dimethyl sulphide derived SO<sub>2</sub> to organic (microgel) emissions from sea-ice leads and polynyas. However, models struggle to reproduce observed Arctic cloud condensation nuclei (CCN) and cloud droplet concentration using existing nucleation parameters, aerosol processes and global emission inventories. Furthermore, while it is possible to 'fill the gap' in modelled CCN with numerous tuned emission fluxes or processes, the response of Arctic cloud albedo to sea-ice retreat is likely predicated on the assumed dominant aerosol source. Here, we discuss the urgent 'problem with Arctic clouds' in global climate models. We introduce novel modelling methods which could inform observation site and technique. Finally, we call for a combined use of modelling and observational techniques across diverse fields to understand the aerosol nucleation process in the Arctic boundary layer and the likely significant but unconstrained role of biological sources in the formation of Arctic clouds.

## **1.048 Multiphase atmospheric chemistry in cold regions .**

Presenting Author:

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Abstract:

Chemical interactions between the gas and condensed phases are increasingly recognized as playing major roles in atmospheric chemistry. Gas-cloud and gas-aerosol interactions have global impacts on aerosol loadings and oxidant levels. In cold regions, multiphase chemistry with frozen surfaces and liquid-like layers play additional, poorly constrained roles, which are evolving due to global environmental change. I will motivate and present a scheme for comprehensive modeling of multiphase chemical processes in cold regions.

## 1.049 Spectroscopic Characterization of Anisole at the Air-ice Interface: Distribution of Organic Pollutants on the Ice Surface..

Presenting Author:

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**Petr Klán**, RECETOX, Faculty of Science, and ‡Department of Chemistry, Faculty of Science, Masaryk University, Kamenice 5, 625 00 Brno, Czech Republic

Abstract:

The absorption, diffuse reflectance, and emission spectra of anisole deposited on snow and ice matrices using different methods (slow freezing, shock freezing, or vapor deposited)[1] provide useful information about its distribution at the air/ice interface. Our experimental spectroscopic data exhibited characteristic bathochromic shifts connected with excimer formation due to the freeze concentration effect[2]. Computational interpretation of these data suggested that anisole molecules aggregate with a significant ring overlap.

[1] Kania, R.; Malongwe, J. K.; Nachtigallová, D.; Krausko, J.; Gladich, I.; Roeselova, M.; Heger, D.; Klan, P. Spectroscopic properties of benzene at the air-ice interface: A combined experimental-computational approach. *J. Phys. Chem. A* **2014**, *118*, 7535–7547

[2] Bartels-Rausch, T.; Jacobi, H. W.; Kahan, T. F.; Thomas, J. L.; Thomson, E. S.; Abbatt, J. P. D.; Ammann, M.; Blackford, J. R.; Bluhm, H.; Boxe, C.; Domine, F.; Frey, M. M.; Gladich, I.; Guzman, M. I.; Heger, D.; Huthwelker, T.; Klan, P.; Kuhs, W. F.; Kuo, M. H.; Maus, S.; Moussa, S. G.; McNeill, V. F.; Newberg, J. T.; Pettersson, J. B. C.; Roeselova, M.; Sodeau, J. R. A review of air –ice chemical and physical interactions (AICI): liquids, quasi-liquids, and solids in snow. *Atmos. Chem. Phys.* **2014**, *14*, 1587–1633.

## **1.050 I<sup>3</sup>CE: Vision for collaborative, international, interdisciplinary study of ice chemistry in the environment.**

Presenting Author:

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Abstract:

Environmental ice is complex and diverse from a microphysical and chemical standpoint. Because of technical challenges involved in laboratory experiments involving ice (and limited resources, and the lack of means for coordinating research across laboratories), our fundamental understanding is restricted to highly idealized systems and lags behind the needs of modelers. Huge gaps exist in our knowledge of the microphysical location of reacting species, ice surface state as a function of environmental conditions, and the impacts of these factors on reaction rates and important pathways. This requires modelers to make simplifying assumptions of unknown accuracy.

The I<sup>3</sup>CE project is founded with the overarching goal of improving our understanding of chemical interactions between the atmosphere and the cryosphere, and their impacts on the environment. In order to effectively address these issues, it is essential that we understand interactions among components of the system and potential feedbacks at their most fundamental levels. We propose an unprecedented coordinated effort involving laboratory and modeling studies spanning molecular to global scales (and picosecond to decadal timescales) designed to address the following questions:

1. How do temperature and impurities impact the microphysical state (quasi-liquid layer (QLL)/brine layer) of environmental ice surfaces? What is the impact of different snow and ice morphologies (and different expected QLL/brine regimes) on the chemical mechanisms and kinetics of AICI?
2. How does AICI in cold regions influence the atmosphere and ecosystems on local and regional scales, as well as the rest of the planet? How will this evolve in the context of global environmental change?
3. How do new pollution sources (development) in the Arctic influence AICI on the molecular to the global scale? What are the implications for local and regional air pollution and ecosystem health? How will all of this change as Arctic sea ice continues to decline?

## **1.051 Highlights from NETCARE (Network on Climate and Aerosols: Addressing Key Uncertainties in Remote Canadian Environments).**

Presenting Author:

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Co-Authors:

**NETCARE Team,**

Abstract:

NETCARE (Network on Climate and Aerosols: Addressing Key Uncertainties in Remote Canadian Environments) is a network comprised of researchers from ten Canadian universities (Toronto, UBC, UQAM, Waterloo, UQAR, Laval, Dalhousie, Calgary, Sherbrooke, Victoria) and five partner institutions (Environment Canada, Fisheries and Oceans Canada, Alfred Wegener Institute, Max Planck Institute, Johannes Gutenberg University). It was one of seven networks funded (2013 - 2018) by the Climate Change and Atmospheric Research (CCAR) program at NSERC. NETCARE was designed to address specific aerosol-climate connections that remain poorly characterized, with a focus on 1) carbonaceous aerosol, 2) ice cloud formation and impacts, 3) ocean-atmosphere interactions. A number of novel observational datasets have been obtained using ground-based, ship, and aircraft platforms. These measurements are being used to evaluate the simulations of atmospheric processes in chemical transport and earth system models. This presentation will highlight some of the recent results obtained by the researchers in the network.

## **1.052 Lessons learned from multi-disciplinary research in the cryosphere using mercury as a case study.**

Presenting Author:

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Abstract:

In order to evaluate and predict environmental, global and multi-factor changes, it is necessary to improve our knowledge base on the dynamic, physical-chemical and biological processes of the Earth System's different sub-systems, including the cryosphere, a critical component, indicator and actor in regulating climate. Among the most critical, yet under-studied components of the Arctic cryosphere is seasonal snow, which extends over a third of the Earth's land surface, covering up to 47 million km<sup>2</sup>. Snow cover is a dynamic habitat with a limited lifetime that acts as a medium and a mediator transmitting and modifying interactions among microorganisms, plants, animals, nutrients, the atmosphere and soil. Due to the cold conditions and the limited supply of liquid water, snow has long been considered as an entrapment and storage system for microorganisms, nutrients, soluble inorganic and organic matter and contaminants delivered by wet and dry deposition. However, this view has begun to change with the publication of a number of studies that examined microbial diversity, ecology, and function in the cryosphere. Microorganisms may also be responsible for the metabolism and transformation of environmental contaminants such as mercury, a pollutant of arctic ecosystems. Using mercury as a case study, we will demonstrate how multi-disciplinary research projects that connect physics, chemistry and biology can lead to new information regarding contaminant cycling in the arctic. We will discuss our work in a broader context to highlight how it would benefit from international collaborations and wider trans-disciplinary research questions.

## 1.053 Air-snow exchange of nitrogen oxides and ozone at a polluted mid-latitude site.

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Abstract:

Vertical gradients of  $O_3$ ,  $NO$ ,  $NO_2$  and  $NO_y$  were measured within and above the snowpack between January 17 to February 14, 2014 as part of the Uintah Basin Winter Ozone Study. During the first half of the campaign, the snowpack was relatively aged and contained high levels of inorganic ions and dissolved and particulate organics. A snowfall on Jan 31 added 5 cm of fresh snow with lower solute concentrations to the top of the snowpack. Vertical gradients ( $DC = C_{(25\text{ cm})} - C_{(125\text{ cm})}$ ) in the measured gas phase species were used to investigate the role of the snowpack as a source or sink. Small positive gradients were seen for  $NO$ , peaking in the middle of the day, which much larger negative gradients were seen for  $O_3$  and  $NO_y$ . Comparing the fresh to the aged snowpacks, there was a noticeable decrease in the gradient for  $O_3$ , but not for  $NO_y$  over the fresh snow, implying a chemical control of  $O_3$  deposition to the snow. The ratio of the gradient of  $NO_x$  to the gradient of  $NO_y$  was used to determine a snowpack  $NO_y$  recycling ratio (emission/deposition) of approximately 4 %, consistent with independent estimates of low nitrate photolysis rates inferred from nitrogen isotopes by Zatzko et al., (2016).

Reference

Zatzko et al., The magnitude of the snow-sourced reactive nitrogen flux to the boundary layer in the Uintah Basin, Utah, USA, *Atmos. Chem. Phys.*, 16, 13837-13851, 2016.



## **1.054 Sea Salt Aerosol from Blowing Snow above Sea Ice - observed evidence of a missing source.**

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Abstract:

Atmospheric particles in the polar regions consist mostly of sea salt aerosol (SSA). SSA plays an important role in regional climate through influencing the surface energy balance either directly or indirectly via cloud formation. SSA irradiated by sunlight also releases halogen radicals, which control concentrations of ozone, a pollutant and greenhouse gas. However, models under-predict SSA concentrations in the polar regions during winter suggesting a missing source. It has been suggested that salty blowing snow above sea ice, which is evaporating, may produce more SSA than equivalent areas of open ocean and therefore explain the model bias. However, only recently it has been possible to carry out the challenging measurements in the polar sea ice zone, which are needed to test the model hypothesis.

We discuss winter/spring observations and their wider implications from recent two sea ice cruises, one in the Weddell Sea / Antarctica (BLOWSEA 2013) and the other in the Arctic Ocean (N-ICE 2015). We particularly highlight challenges and synergies in two international and highly trans-disciplinary project collaborations with CATCH objectives, i.e. quantification of source strength and climate impacts of particles produced in cold regions.

## **1.055 Science Community Input for CATCH - a new Initiative on Chemistry, Biology and Physics in Cold Regions.**

Presenting Author:

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Abstract:

The Cryosphere and ATmospheric CHemistry (CATCH) is a new emerging activity endorsed by IGAC and co-sponsored by SOLAS. The CATCH mission is to facilitate atmospheric chemistry research within the international community, with a focus on natural processes specific to cold regions of the Earth. Cold regions include areas which are seasonally or permanently covered by snow and ice, from the high mountains to the polar ice sheets and sea ice zones as well as regions where ice clouds that undergo chemistry are found.

As a base for workshop discussions I present an overview of the feedback provided by the CATCH community through an online survey on how to shape future actions. The summary includes among others the spread of nationalities and scientific disciplines represented by participants, the main benefits of coordinated trans-disciplinary and international activities as seen by the community, and suggestions for big picture science questions in cold regions to be addressed by future CATCH actions.

## 1.056 HONO over polluted mid-latitude snow.

Presenting Author:

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Abstract:

The role of wintertime nitrous acid, HONO, as an important OH radical precursor has received renewed attention with the observation of large HONO mixing ratios over snow influenced by emissions from gas and oil drilling activities. These HONO observations, which have been linked to ozone mixing ratios exceeding the US federal air quality standard, have raised questions on the accuracy of atmospheric HONO measurements, in particular in cold climates. In addition, they motivate further study of the HONO flux in and out of the snow, as well as its chemical formation mechanism in/on snow.

We will use HONO measurements performed by several different instruments during a field experiment in wintertime Utah, to discuss the current state of HONO observations over snow. Vertical HONO gradients and fluxes, measured using long path Differential Optical Absorption Spectroscopy, will be compared to our current knowledge of snow HONO chemistry to identify current knowledge gaps. Finally we will identify and discuss future activities to elucidate HONO, and more generally  $\text{NO}_x$ , chemistry in and above snow, as well as the impact of transport limitations in the coupled snow-atmosphere system.

## **1.057 International Arctic Systems for Observing the Atmosphere (IASOA) A System Science Consortium.**

Presenting Author:

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Abstract:

International Arctic Systems for Observing the Atmosphere (IASOA) is a voluntary consortium of Arctic Atmospheric researchers focused on coordinating intensive measurements of the Arctic atmosphere collected in the United States, Canada, Russia, Norway, Finland, and Greenland to create synthesis science that leads to an understanding of why and not just how the Arctic atmosphere is evolving. The IASOA premise is that there are limitations with Arctic modeling and satellite observations that can only be addressed with in situ observations and that the potential of combining individual station and network measurements into an integrated observing system is tremendous. The IASOA vision is that by further integrating with other network observing programs focusing on hydrology, glaciology, oceanography, terrestrial, and biological systems it will be possible to understand the mechanisms of the entire Arctic system, perhaps well enough for humans to mitigate undesirable variations and adapt to inevitable change.

The official mission statement of IASOA is to advance coordinated and collaborative research objectives from independent pan-Arctic atmospheric observatories through (1) strategically developing comprehensive observational capacity, (2) facilitating data access and usability through a single gateway, and (3) mobilizing contributions to synergistic science and socially-relevant services derived from IASOA assets and expertise. IASOA has an emphasis on concrete outcomes such as installation of new instrumentation, development of cross observatory coordinating operating procedures, creation of the data sets, support of an access portal to acquire digital files suitable for fundamental research, publication and presentation of original research developed by international teams of experts and mobilization of the IASOA network to support national and international research programs. IASOA supports the organization of thematic (aerosols, clouds/radiation, transports, trace gases, surface-atmosphere exchanges, observations/data) working groups that have overlapping objectives with CATCH.

## 1.058 ON THE MEASUREMENT OF GAS PHASE HALOGENATED SPECIES.

Early Career Scientist

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Abstract:

Halogenated species have huge impact on atmospheric composition in troposphere. They also involve in particle formation process which potentially has an enormous impact on climate. Homogeneous nucleation via  $\text{HIO}_3$  addition has been indicated to be an important source of iodine-containing particles at Mace Head [1]. However, the chemistry mechanism behind the formation of  $\text{HIO}_3$  has only been calculated by quantum mechanism [2][3]. There is a need to investigate the mechanism experimentally. In this work, we will present the formation mechanism of  $\text{HIO}_3$ .

We will also present a chemical ionization mass spectrometry method, which has the ability to detect a series of gas phase iodine-containing compounds, including  $\text{HIO}_3$ ,  $\text{HIO}_2$ ,  $\text{HIO}$ ,  $\text{HI}$ ,  $\text{IO}$ ,  $\text{IO}_2$ ,  $\text{I}_2\text{O}_2$ ,  $\text{I}_2\text{O}_3$ ,  $\text{I}_2\text{O}_4$ ,  $\text{I}$  and  $\text{I}_2$  in laboratory condition. Moreover, the results also show that it has the potential to measure bromine and chlorine containing species. This method needs to be tested in ambient environment to confirm its ability, as well as its sensitivity toward different halogenated species. Moreover, inter-comparison between this instrument and other instruments which measure different halogenated species is needed. Collaboration with experts in halogen measurements and sites with halogen emissions will potentially lead to a comprehensive way of measuring gas phase halogenated species within one single instrument.

## 1.059 Understanding the Impact of Biomass Burning on Ozone Conditions in the Arctic.

Early Career Scientist

Presenting Author:

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Abstract:

Tropospheric ozone is an atmospheric species formed by the reaction of precursor species (NO<sub>x</sub>, CO, VOC's) in the presence of UV radiation and drives complex interactions which can result in impacts on atmospheric conditions in the Arctic. As an important greenhouse gas, ozone has a significant influence on the photochemical characteristics, oxidation capacity, and radiative forcing of the atmosphere and at high levels has negative impacts on public health and overall ecosystem functioning. In the Arctic, tropospheric ozone has variable characteristics in time and space. The arctic ozone conditions are strongly influenced by seasonal destruction events, arctic haze, transport of pollution from Asia and influence from precursor compounds released from wildfires. Surface ozone measurements have been made in the arctic since 1973 (Barrow, Alaska) and have expanded spatially and temporally since. This study analyzes the relative impact of biomass burning on surface ozone conditions from six arctic measurement locations. The meteorological and chemical conditions of the atmosphere are examined to help explain variation in the arctic surface ozone conditions. Co-located measurements of meteorological conditions, carbon monoxide, and aerosol optical depth are used to understand the dominant sources of pollution, pollutant composition, and the interactions due to meteorological conditions that result in anomalies in the observed ozone mixing ratios. However, there is still a need for additional information and measurements of chemical tracers to help discern the contributions of different pollutant sources to ozone conditions. NOAA Hypsilit back-trajectory analysis, satellite imagery, smoke verification models, and NCAR Community Earth System Model are used to

interpret observations as a result of the limited geographical and temporal coverage of measurements required for attribution of pollution sources. Characterization of ozone conditions is essential for understanding the spatial and temporal variation and behavior of ozone as it relates to climate change in the arctic.



## **1.060 Hierarchy of models for improving the understanding of snow and ice chemistry and its interactions with atmospheric chemistry in the Arctic.**

Presenting Author:

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Abstract:

Atmospheric boundary layer (ABL) and its underlying snow cover constitute a multiphase system for reactive compounds to foster their photochemical interactions and mass exchange occurring at the timescale of hours to days. The buildup of reactants can be contained in the shallow ABL under calm weather, whereas, under weather disturbances, the air mass can be transported horizontally afar and lifted vertically above the ABL. The prevalence and intensity of such snow-induced photochemical events vary according to the seasonal progression of the physico-chemical state of snowpacks. To address scientific questions concerning the behavior of bromine, ozone and mercury in the Arctic environment at various spatial and temporal scales of interest, we have developed a suite of models at various complexities in their process representations. PHANTAS is a process-oriented, one-dimensional multiphase reaction-diffusion model that resolves the different physical and transport properties across the ABL and the porous snowpack while using a detailed chemical mechanism common to both model regimes. The model currently employs an uncertain assumption that the liquid-like layer as a substrate hosts the reactions on the surface of snow grains, which should be replaced by a better representation of reality in the heterogeneous mixture of solid and liquid-like entities on the surface of ice matrix based on a consensus developed through international collaborations. For a comprehensive assessment of the regional chemistry and transport of mercury, we have developed two flavors of a three-dimensional coupled operational meteorology-chemistry model. One of them includes explicit chemical mechanism for bromine and mercury compounds, whereas another one employs highly-parameterized bromine chemistry and surface biogeochemical cycles. Observational field and satellite data obtained by international community benefit the evaluation of simplified as well as phenomenological process representations in such models. We will discuss the current status of these models and the path forward.

## 1.061 Snowpack Molecular Halogen Production in the Springtime Arctic.

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Abstract:

Snowpack photochemistry is as an efficient source of molecular bromine ( $\text{Br}_2$ ) to the Arctic troposphere with significant impacts on the oxidation of ozone and mercury. Recent work has highlighted the abundance of  $\text{Cl}_2$ , from which Cl atoms accelerate the oxidation of hydrocarbon pollutants, including the greenhouse gas methane. During recent experiments near Utqiagvik (Barrow), Alaska in spring 2014 and 2016, we further investigated the coastal snowpack as a source of molecular halogens, focusing on the production of  $\text{Br}_2$ ,  $\text{Cl}_2$ ,  $\text{BrCl}$ , and  $\text{I}_2$ . The conditions of observed molecular halogen production provide insights into prevalent chemical mechanisms, and the first measurements of  $\text{Br}_2$  and  $\text{Cl}_2$  snowpack fluxes provide guidance for modeling efforts. Zero- and one-dimensional modeling are utilized to examine the resulting snowpack interstitial air and near-surface chemistry.

## 1.062 Marine Aerosol Production and Chemical Composition in the Arctic.

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Abstract:

The Arctic is undergoing extreme climate change with sea ice extent declining rapidly. With greater open ocean during summer and the potential for production from leads (open water breaks in the sea ice) during fall-spring, marine aerosol and trace gas emissions are predicted to be increasing. The chemical composition of these individual particles controls their climate impacts, and given the challenges of Arctic measurements and the evolving nature of atmospheric particles, significant uncertainties remain in our understanding of particle production, chemical composition, gas-particle partitioning, and participation in heterogeneous reactions in the Arctic. Using multiple years of atmospheric particle chemical composition and sea ice radar data at Utqiagvik, Alaska, we examined the environmental controls on coastal sea salt aerosol production, finding that leads, similar to open water, are a source of sea salt aerosol under elevated wind speeds. During periods of leads and open water, the chemical composition of atmospheric particles was examined for samples collected in Utqiagvik, Alaska during January-February 2014 and August-September 2015. For both time periods, computer-controlled scanning electron microscopy with energy dispersive X-ray spectroscopy (CCSEM-EDX) and Raman microspectroscopy analyses were utilized to probe the morphology and chemical composition of individual particles. The presence and identity of organic coatings on sea spray aerosol particles were examined for the first time in the Arctic. In addition, we examined the prominent pathways of heterogeneous reactions on the sea spray aerosol.

## **1.063 Research opportunities at Villum Research Station in North Greenland for climate relevant studies. A new research infrastructure.**

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Abstract:

In 2013 a grant from the Villum Foundation made it possible to build a new modern research Station at Station Nord in North Greenland, High Arctic with all the facilities to host research groups from almost all natural science disciplines. The Station named Villum Research Station (VRS) includes 6 laboratories; a "dirty" laboratory, a chemical laboratory, a microbiological laboratory and a cleaner laboratory (though not following a certified standard) and finally a house dedicated to atmospheric measurements. This house is equipped with two atmospheric monitoring laboratories and it is located 2 km from the center of Station Nord in order to minimize local contamination. The station is at 81° 36'5.26" N, 16° 39'43.31" W, 24 m ASL and is open year round. The location is where the winter transport of pollution from Eurasia via Siberia first hit land again after being transported up over the North Pole. Furthermore the ice stream from the Arctic Ocean is along the east coast of Greenland and thus multi-year and seasonal ice is transported right to the "door" of the station. Finally the area is one of the areas where the highest temperature increase is predicted. Thus, the station has an ideal position for investigating the causes and consequences of a still warmer climate on Earth and can

serve as a sentinel for global change. The facilities make it possible study the changes in High Arctic and how they affect the biosphere, atmosphere, geosphere, cryosphere and marine environment.

In the presentation the possibilities for doing research at VRS will be described and examples of what have already been accomplished. Finally future plans will shortly be listed for the next three years including a larger campaign together with Alfred Wegener Institute in 2018 and how the Station can contribute to MOSAIC.

## 1.064 Tracing the origin of black carbon deposition over the Greenland ice sheet to forest fires in Canada.

Presenting Author:

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Abstract:

The processes that result in aerosol deposition within the Arctic are currently a key uncertainty in our ability to understand Arctic change. Aerosol deposition is a dominant source of light-absorbing impurities, including black carbon, found in Arctic ice and snow. Trace amounts of light absorbing impurities in snow are important because they are used to interpret past pollution trends (e.g. fire frequency) using ice cores and because they have important climate impacts (warming) due to their modification of snow and ice albedo. Here, we focus on the role of biomass burning in controlling the amount of black carbon deposited on the Greenland ice sheet. We study a specific case of aerosol

deposition to the Greenland ice sheet by combining extensive snow pit measurements with simulations using the regional model WRF-Chem. Light absorbing impurities were measured in snow pits (in 2014) and snow accumulation rates (2013-2014) were monitored at several remote sites on the Greenland ice sheet as part of the SAGE project. The largest black carbon deposition quantity measured was traced to a snow accumulation event that occurred in late July and early August 2013. In order to understand the origin and identify the processes controlling the observed deposition event, the regional model WRF-Chem is used (run from 17 July - 5 August 2013) combined with satellite observations (MODIS and CALIPSO/CALIOP). The model simulation includes anthropogenic and fire emissions in North America as well as transport and chemical/physical transformations of aerosols. Model results show that the observed deposition event can be traced to fires burning in northern Canada in late July 2013. The processes controlling aerosol deposition will be discussed including the critical role of transport pathways and wet removal processes, which are essential in controlling the fate of emissions within the Arctic region.

## 1.065 Central Antarctica as a source of atmospheric mercury for lower latitude ecosystems.

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Abstract:

The Antarctic plateau – ice-covered area of ~7 million km<sup>2</sup> – is a highly photochemically active area (Davis et al., 2001) during the sunlit period with oxidant concentrations approaching those of tropical or urban mid-latitude environments (Kukui et al., 2014). Earlier studies (Brooks et al., 2008; Dommergue et al., 2012) carried out on the high-altitude Antarctic plateau with modern instruments also suggested, based on short-term observations (a few weeks) in summer, an intense reactivity of mercury on the plateau at the air-snow interface.

Recent monitoring studies of atmospheric gaseous mercury Hg(0) at Concordia Station (Angot et al., 2016b) revealed the occurrence of multi-day to weeklong depletion events of Hg(0) in ambient air in summer, that are not associated with depletion of O<sub>3</sub>, and likely result from a stagnation of air masses on the plateau triggering an accumulation of oxidants in the shallow boundary layer. This behavior is radically different from what is usually observed in the Arctic where only mercury depletion events that were associated with O<sub>3</sub> depletion (and with a Hg(0)/O<sub>3</sub> correlation) have been highlighted so far. According to observations at coastal (or near-coastal) Antarctic stations (Angot et al., 2016a)(Pfaffhuber et al., 2012), the reactivity observed at Concordia Station in spring and summer is transported on a continental scale by strong katabatic winds. Hg(II) species can be thus rapidly brought to coastal ecosystems and could provide a source of Hg to coastal and sea-ice organisms. This may explain high values of Hg that are retrieved in bioindicators (Bargagli, 2016), in sea-ice (Gionfriddo et al., 2016) and surface waters (Cossa et al., 2011).

This presentation tries to give an overview of the functioning of the Hg chemistry in central Antarctica and its influence on coastal environments.



## **1.066 How do interfacial exchange rates of biogeochemical process-related trace gases trigger the Arctic climate system? (BGC in MOSAiC).**

Presenting Author:

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Abstract:

The interior Arctic is a unique environment on Earth. Biogeochemical cycles of climate-relevant trace gases (CRTG) in this ice-covered ocean are unique to the region and remain enigmatic compared to those cycles at low latitudes. The Multidisciplinary drifting Observatory for the Study of Arctic Climate (MOSAiC) is planned to develop a year-round process-level observations during ice drift. The coupling of ice and snow physics on one side with the ecosystem on the other side induces numerous biogeochemical reactions during freezing and melting cycles of sea ice, which finally results in trace gas exchange with both the overlying atmospheric boundary layer (ABL) and the underlying, sea ice influenced, ocean down to the halocline. The year-round process-level observations comprise the complexity needed for tracing those pathways and the feedback mechanisms that impact the coupled ocean-ice-snow-atmosphere system. Pathways to consider are: direct interactions, i.e. from ice, snow or water to the ABL and indirect interactions, where trace gases circulate through more than one environment before reaching the ABL. While the ABL is isolated in terms of dynamics and chemistry from the rest of the troposphere, the halocline restricts the exchange with the deeper ocean, favours microbial degradation processes in surface water and keeps biologically produced trace gases seasonally in surface waters while encouraging gas release during storm events. Quantifying those seasonal-varying fluxes is essential for future improvements of climate models. Understanding the processes behind the observed fluxes of climate-relevant trace gases require a detailed knowledge of both chemistry and dynamics, an intense collaboration and a close link to most of the measurements in atmosphere, snow, sea ice, ocean and ecosystem during MOSAiC.

## 1.067 Trace gas and aerosols emissions from boreal wildfires and impact on atmospheric pollution in the Arctic.

Presenting Author:

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Abstract:

Wildfires are a significant source of atmospheric pollutants, including greenhouse gases and aerosols. Among the emitted species, most have long enough lifetimes to be transported over thousands of kilometres. Boreal wildfires are particularly intense and have been shown to strongly influence the interannual variability of several atmospheric pollutants (CO, and aerosols) in the remote Northern Hemisphere, in the Arctic in particular. With a fire risk increasing and fire seasons lengthening as a result of climate change, it is all the more critical to better estimate the large-scale impact from these large events. Impacts should be quantified in terms of atmospheric composition, but also on the radiative balance, cloud microphysics and surface properties (albedo), which may in turn affect atmospheric chemistry. Wildfires are therefore at the centre of complex interactions that are still not well quantified.

Estimating the impact of wildfires necessarily has to rely on an evaluation of fire emissions. In this presentation, we will present the APIFLAME fire emissions' model, applied to boreal regions. A specificity compared to fires in other regions is a representation of the potential burning of the ground organic layer. The variability of fire activity (based on MODIS satellite observations) and the associated emissions over the 2010-2016 time period will be presented. It will be related to atmospheric variations of CO and aerosols using both surface and satellite observations. An analysis of the impact of wildfires on atmospheric composition and of the interactions with meteorology and surface properties requires careful analysis of processes specific to cold areas (ice clouds, snow cover, etc.). This topic will thus clearly benefit from the science developed within the CATCH network.

## 1.068 What are the sources of ice nucleating particles in the high latitudes?.

Presenting Author:

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Abstract:

Mixed phase clouds in the Arctic and Antarctic regions play a central role in climate, but are poorly represented in many models. Liquid water in clouds is inherently unstable and even a very small concentration of ice nucleating particles have the potential to strongly impact cloud properties, lifetime and precipitation. However, the concentration and distribution of these ice nucleating particles is poorly characterised and importantly, the source of these ice nucleating aerosol particles is often unknown. In this presentation I will review our recent published and unpublished research on the potential sources of ice nucleating particles for the high latitudes. In the summertime high Arctic it has been postulated that local marine sources of ice nucleating particles from open leads are important, but the fluxes of these particles is unknown. Alternatively, it has also been suggested that aerosol, such as desert dust, transported into the Arctic above the cloud layers is key to supplying these clouds with ice nucleating particles. In the Southern Ocean, around Antarctic, many clouds are characterised by a propensity to supercool much greater than clouds in much of the northern hemisphere. In these clouds, we have suggested that marine organics associated with sea spray control ice nucleation, but there are very few measurements of ice nucleating particles, aerosol properties and cloud properties in this region.

Addressing these questions requires collaborative interdisciplinary efforts. Making measurements of ice nucleating particles concentrations and identifying sources of this special aerosol type is key to addressing the poor representation of mixed phase-high-latitude clouds. Accessing regions such as the high Arctic and the Southern Ocean clearly needs to be a community effort. A multi-disciplinary approach is needed to, for example, establish the quantitative linkages between ocean biogeochemistry, the flux of marine organic ice nucleating materials and the subsequent impact on clouds.

## 1.069 Quantitatively relating air mass history and meteorology to boundary layer ozone depletion events over the Arctic Ocean.

Early Career Scientist

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Abstract:

The springtime episodic depletion of boundary layer ozone in polar regions has been actively researched over 30 years. It is widely believed these events chemically originate over the frozen Arctic Ocean, which provides the necessary atmospheric conditions and reactive halogen species (primarily molecular bromine) necessary for the underlying chemistry. In this study, we utilize data from deployments of buoy-based observatories (O-Buoys and Icelanders) across the Arctic Ocean to quantify the relationship between meteorology, air mass history as it relates to satellite-determined sea ice imagery, and ambient ozone mole fractions. Time periods analyzed in this work range from March through June in 2010-2012, and 2014-2016, with the majority of measurement sites revolving around the Beaufort Sea. These long-term in situ measurements can provide unique insights into the effects local surface type and meteorology have on the timing, frequency, and duration of ozone depletion, and the recovery from those events. Initial results are consistent with the hypothesis that the Arctic Ocean is widely O<sub>3</sub>-depleted in the Arctic springtime, and that ozone recoveries are caused by vertical mixing from

highly intermittent turbulent conditions. We found  $R^2$  as high as 0.68 when comparing  $O_3$  observations with meteorology, while the maximum  $R^2$  based on air-mass history and  $O_3$  reached as high as 0.45. We also intend to relate  $O_3$  observations with satellite retrievals of snow depth. The O-Buoy data sets, from 2009-2017, including meteorology, surface  $O_3$ , BrO, and  $CO_2$  measurements, represent a highly unique data set rich in opportunity for study and collaboration with any and all Cryosphere and ATmospheric Chemistry (CATCH) community members. We will continue studying the relationship between meteorology, sea surface type, and  $O_3$  depletion events using the existing O-Buoy data sets, and will provide the data to prospective collaborators.

## **1.071 Long Term Ecological Research at the Lautaret Station: the FluxAlp project.**

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Abstract:

Alpine grasslands are hot-spots of biodiversity often maintained by traditional agricultural practices. Nitrogen, as limiting nutrient, exerts a strong control on plant growth and plant community composition on which many crucial ecosystem services rely, such as carbon storage and water quality. Nitrogen input in mountains has increased recently and will increase again in the coming decades through human influence on atmospheric deposition. Another strong control on alpine ecosystem is snow, as it affects physical parameters such as ground temperature and PAR flux in the spring, and conditions nutrient input to the soils through spring melting after winter accumulation; and snow cover is also expected to change drastically in the coming decades. Yet the mechanisms through which those changes operate are still poorly understood.

Long Term Ecosystem Research stations are needed to better constrain our understanding of those mechanisms. The Alpine Station at Col du Lautaret (2100m asl) was at first a botanical garden, and has been used for botanical and ecological research for several decades. Recent investments (CO<sub>2</sub> and H<sub>2</sub>O flux measurements, atmospheric nitrogen deposition, nutrient export at the catchment outlet) at the Lautaret Station aim at making it a good platform for such long term studies.

Recent experiments include tracing of atmospheric nitrate influx in the ecosystem through the use of d<sup>15</sup>N and D<sup>17</sup>O isotopic signatures, which showed the influence of past agriculture practices on nitrate processing by the most common plants in the ecosystem.

Future planned experiments include a detailed monitoring of water and carbon fluxes in relation with the nitrogen input at snow melt, to better understand the dynamic relation between the nutriment influx and vegetation onset.



## **1.072 Development of the Finse Alpine Research Station towards a platform for multi-disciplinary research on Land-Atmosphere Interaction in Cold Environments (LATICE).**

Presenting Author:

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Abstract:

The Finse Alpine Research Station provides convenient access to the Hardangervidda mountain plateau in Southern Norway (60 deg N, 1222 m asl). The station is located above the tree-line in vicinity to the west-eastern mountain water divide and is easily accessible by train from Bergen and Oslo. The station itself offers housing and basic laboratory facilities and has been used for ecological monitoring. Over the past years, studies on small-scale snow distribution and ground temperature have been performed and accompanied by a suite of meteorological measurements. Supported by strategic investments by the University of Oslo and ongoing research projects, these activities are currently expanded and the site is developed towards a mountain field laboratory for studies on Land-Atmosphere Interaction in Cold Environments, facilitated by the LATICE project ([www.mn.uio.no/latice](http://www.mn.uio.no/latice)). Additional synergy comes from close collaborations with a range of institutions that perform operational monitoring close to Finse, including long-term time series of meteorological data and global radiation. Through our activities, this infrastructure has been complemented by a permanent tower for continuous Eddy-Covariance measurements along with associated gas fluxes. A second, mobile covariance system is in preparation and will become operational in 2017. While the research focus so far was on small scale processes (snow redistribution), this is now being expanded to cover hydrological processes on the catchment and regional scale. To this end, two discharge stations have been installed to gauge discharge from two contrasting catchments (glacier dominated and non-glacierized). In this presentation, we provide an overview over existing and planned infrastructure, field campaigns and research activities, accompanied by available data, the result of some preliminary analysis and discuss opportunities for future collaboration.