Lecture Presentations

Presenting author	Eivind Straume University of Oslo/CEED
Title	Cooling of the Northern Hemisphere triggered by Northeast Atlantic opening at the Eocene – Oligocene Transition
Key words	paleogeography, paleoclimate, oceanic gateways
Abstract	The Eocene – Oligocene Transition (~33.7 million years ago), marks the largest step transformation within the Cenozoic cooling trend, and is characterized by a sudden growth of the Antarctic ice sheets and the establishment of strong meridional temperature gradients. The role of changes in oceanic basin configuration and the evolution of key oceanic gateways in triggering the climatic variations occurring at this time remains disputed. Here, we examine the climatic impact of oceanic gateway events at the Eocene – Oligocene Transition by implementing new paleogeographic reconstructions with new realistic paleobathymetric models for the Atlantic – Arctic basins in a state-of-the-art Earth System Model (NorESM-F). We show that the Eocene climate is highly sensitive to depth variations of the Greenland – Scotland Ridge and the existence of the proto-Fram Strait. Opening the Atlantic – Arctic oceanic gateways cause freshwater leakage from the Arctic Ocean preventing deep water formation in the North Atlantic, reducing the northward ocean heat transport, and thereby causing a significant cooling of the Northern Hemisphere.

Presenting author	Artem Moiseev Nansen Environmental and Remote Sensing Center
Title	On Removal of Sea State Contribution to Sentinel-1 Doppler Shift for Retrieving Reliable Ocean Surface Currents
Key words	Ocean surface current, Sentinel-1, Doppler shift, Sea State
Abstract	The Sentinel-1 is an ongoing Synthetic Aperture Radar (SAR) mission which continuously provides observations over the ocean since 2014, with scheduled performance time until 2035. However, a challenging calibration of the Sentinel-1 acquisitions and lack of sophisticated geophysical signal separation schemes for the wave and current contributions disabled usage of these data for retrieving of reliable ocean surface current information. Recently an accurate Sentinel-1 signal calibration became available thanks to the telemetry from the instruments operating on board of the satellite. In this study, we take advantage of this new calibrated Sentinel-1 dataset collocated with wind and wave fields from the ECMWF and WAVEWATCHIII models to develop an empirical model for estimating the wave-induced contribution to the signal and, in turn, derive improved estimates of the ocean surface current. Moreover, we evaluated acquired ocean surface current retrievals using conventional ocean surface drifter observations based on available data. We found that combining wind and wave information in the empirical model yield significant improvements in the accuracy of the wave-induced contribution estimates. We also indicated that the conventional empirical models, trained on historical satellite observations with coarser resolution, should not be routinely applied to the Sentinel-1 data. Given wave bias estimates from the developed model, SAR derived ocean surface current is consistent with conventional ocean surface drifter observations. Therefore, Sentinel-1 observations can be used to systematically study ocean surface currents with a 20 km resolution at a monthly time scale.

Presenting author	Naima El bani Altuna University of Tromsø/CAGE
Title	Bottom water temperature changes and water mass exchange through the Fram Strait in relation glacial millennial-scale climate oscillations
Key words	Mg/Ca, Benthic foraminifera, Heinrich Stadial, stable isotopes, Fram Strait
Abstract	The western Svalbard margin is a key area for the reconstruction of water mass and heat exchange between the North Atlantic and Arctic Ocean through the Fram Strait in relation to abrupt climate changes as seen in glacial Greenland Interstadial and Greenland Stadial (GI-GS) events. Here, we present a bottom water temperature (BWT) record from the northern Nordic Seas (79°N) at 1273 m water depth based on benthic foraminiferal Mg/Ca. The BWT reconstructions, combined with benthic foraminiferal stable isotopes, benthic foraminiferal fauna compositions, grain-size distributions and IRD counts, reveal at least two distinctive scenarios for the GI-GS events during the last glacial period (13–63 kyr before 2 kyr (b2k)). During GIs, conditions were similar to modern with high productivity and low BWT and convection was re-stablished. During GSs and in particular during Heinrich Stadials (HS) BWT increases up to 5°C generally concomitant with low planktic and benthic δ18O. Our results suggests, that during some GSs and HSs, deep water generation was reduced, allowing the subsurface Atlantic water to thicken and deepen down to at least the core site depth. A strong halocline during GSs prevented heat release from the subsurface Atlantic water, which we can now trace from 45ºN in the North Atlantic to the Arctic Ocean >79ºN. Surfacing of the salty Atlantic subsurface water pre-conditioned the Nordic seas for convection. Release of the subsurface heat from this vast reservoir must have contributed significantly to the large and abrupt atmospheric warmings at the start of Greenland Interstadials.

Presenting author	Sofia Elisabeth Kjellman University of Tromsø
Title	Holocene precipitation seasonality in Svalbard inferred from δ2H of sedimentary leaf waxes
Key words	lake sediment, hydrogen isotopes, n-alkanoic acids, precipitation seasonality, Holocene, Arctic
Abstract	Arctic precipitation is predicted to increase in the coming century, due to a combination of greater northward atmospheric moisture transport and enhanced local surface evaporation from ice-free seas. This hydrological intensification will impact Arctic ecosystems, glacier mass balance, and infrastructure. Our understanding of the mechanisms behind Arctic precipitation changes is limited due to high spatiotemporal variability and lack of long-term observations. In the absence of instrumental data, paleoclimate data are necessary to fill this critical knowledge gap. We use lipid biomarkers in lake sediments from Svalbard to quantify precipitation variability during earlier Holocene warm periods. Leaf waxes are produced by plants, and record the hydrogen isotopic composition (δ2H) of the source water during photosynthesis: lake water for aquatic plants and soil water for terrestrial plants. Source water δ2H is controlled by moisture source, temperature, evaporative enrichment and lake water residence time. Depending of the residence time and source of lake water, δ2H of aquatic plant may reflect summer or mean annual precipitation δ2H values. By measuring δ2H of n-alkanoic acids (C22 for aquatic plants and C28 for terrestrial plants) in lake sediments from a transect of lakes on Svalbard, we study latitudinal gradients in Holocene precipitation seasonality. Furthermore, we investigate modern controls of δ2H in precipitation and lake water to support our interpretations of the paleorecords.

Presenting author	Kristine Flacké Haualand University of Bergen/GFI
Title	How heat and moisture from the ocean affects cyclone development
Key words	surface fluxes, storm development
Abstract	Surface sensible and latent heat fluxes can impact the development of midlatitude cyclones in various ways depending on the environmental conditions. In a highly idealised model, where surface fluxes are parameterised in various ways depending on local conditions, we find that the direct effect of surface fluxes reduces cyclone growth by weakening the local temperature contrast between the cold and the warm sectors of the cyclone, whereas the indirect effect of surface fluxes enhances cyclone growth by providing additional moisture sources that lead to enhanced cloud condensation. For typical environmental conditions, the indirect effect dominates over the direct effect, such that the net effect of surface fluxes intensifies midlatitude cyclones.

Presenting author	Patrick Johannes Stoll University of Tromsø
Title	Polar lows as moist-baroclinic cyclones in four vertical-shearenvironments
Key words	polar low, cold-air outbreak, self-organising maps, ERA-5
Abstract	Polar lows are small, but intense cyclones that develop in the marine polar air mass. They appear in a large variety. We classify polar lows with regard to their environment in which the cyclogenesis and system maintenance occurs by applying self-organising maps. The method is applied to 370 polar lows from the N-E Atlantic, which were obtained by matching mesoscale cyclone tracks from the reanalysis ERA-5 with polar lows listed by the Norwegian meteorological institute (STARS-dataset). ERA-5 reproduced most (92%) of the polar lows. The classification reveals that polar lows develop in four different vertical shear configurations. These are characterised by the vertical shear angle that provides the angle between the thermal wind vector and the direction of the background flow. We show that the shear angle organises the dynamics of the systems. This confirms the usefulness of the categorisation into forward and reverse-shear polar lows in order to describe the dynamical configuration. We further expand this categorisation by right and left-shear polar lows that propagate towards colder and warmer environments, respectively. Systems in all four shear categories intensify by moist baroclinic instability. Evidence for a hurricane-like mechanism contributing to polar-low intensification is not found.

Presenting author	Emilie Claussen Iversen University of Oslo/GEO
Title	Improvements to melting snow behavior in a bulk microphysics scheme
Key words	Precipitation; melting snow; fall velocity; microphysics; NWP; winter storms
Abstract	Snow falling into a melting layer will eventually consist of a fraction of meltwater and hence change its characteristics in terms of size, shape, density and fall speed. Most microphysical arameterizations in numerical weather prediction models typically only represent purely solid or liquid hydrometeors. Generally, this has been an acceptable compromise since the melting layer is typically very shallow and adding a mixed solid/liquid particle type would result in increased computational time. This research shows how improvements were made to the treatment of melting snow in a microphysical parameterization within the Weather Research and Forecasting (WRF) model by implementing an approximation of snowflake melted fraction together with a physically-based expression for melting particle terminal velocity. In addition, the more appropriate definition of melting level defined by the wet-bulb temperature was consistently used in various process rates, all while not adding additional prognostic variables that would add computational cost. Multiple events observed during the 2015 – 2016 Olympic Mountain Experiment (OLYMPEX) were used to compare with the WRF model results. The modified scheme is able to represent disdrometer observations of joint particle size and fall velocity during wet snow events, as well as fall velocity profiles through the melting layer derived from a vertically-pointing radar. The improved scheme removes 'bulls' eyes' of snow accumulation in lee-side areas within the melting zone, and should result in better predictions of surface precipitation phase and amount.

Presenting author	Mika Lanzky University of Oslo/GEO
Title	Observations of isotope signatures of water vapour, snowfall and snow pack at Finse
Key words	observations, isotopes, fieldwork, atmospheric water cycle, snow, moisture source
Abstract	Stable water isotopes is a naturally build-in tracker of the water cycle. The primary quantities, dD, d18O, d17O, and the secondary parameters, d-excess and 17O-excess, gives information about the origin and transport history of moisture from its source to its sink. When precipitation comes in the form of snow, it settles on the ground and act as a pseudo-sediment, building up a record in the form of a snowpack over the season. In the winter of 2018-2019, a measurement campaign of stable water isotopes was carried out in Finse for main period of two monhts: snowfall was sampled daily and on higher temporal resolution with a simple, manual set-up, while the water vapour was continously measured using a Picarro L2130i/L2140i with heated inlet. Throughout the season, five snow pits were sampled for isotopes and accompanying stratigraphy. In total over 400 snow samples were taken. We use these observations to investigate how moisture source information is converted from an atmospheric signal to a deposited record in the snow pack. In addition, we compare these in situ observed isotopic signatures with moisture source tracking analysis from a Langrarian diagnostic.

Presenting author	Sonja Wahl University of Bergen/GFI
Title	Quantification of stable water isotope exchange between snow surface and lower atmosphere by direct flux measurements
Key words	stable water isotopes, eddy covariance, turbulent fluxes, Greenland Ice Sheet
Abstract	Stable water isotopes are valuable natural tracers within the water cycle that can be used in climate model validation to identify model biases. When preserved in ice, stable isotopes of water are also a fingerprint for local climate variability. The dominant water cycle processes in the cold and dry interior of the Greenland Ice Sheet, are surface fluxes. We present here a method, which allows quantification of the exchange of stable water isotopes through sublimation and deposition. An eddy-covariance approach is combined with laser-based absorption spectroscopy, to directly obtain isotope fluxes. We present observations of isotope fluxes from the top of the Greenland Ice Sheet. The presented observational data will help to understand the imprint of climate in the snow isotopes and will improve parameterizations in isotope enabled climate models.

Presenting author	Alexios Theofilopoulos University of Bergen/GFI
Title	Reconstruction of surface mass balance by using the isochronal layers of the Greenland Ice Sheet.
Key words	Greenland Ice Sheet, Isochronal Layers, Surface Mass Balance, Modelling
Abstract	The interior of an ice sheet is characterized by several layers of accumulated snow. Each one of those layers contains important information on the accumulation, melting and dynamical effects that affected said layer during its history. The project focuses on developing a method that will take advantage of the distribution and shape of those layers as they appear today, in order to reconstruct the surface mass balance of the past. An isochronal numerical method is used for simulating the evolution of a two dimensional, idealized ice sheet. The surface mass balance serves as the model's primary input. The main aim of the project is to develop a data assimilation method that will correct the input by comparing the output of the model with the isochronal layers of a "target" simulation. The objective is to be able to reconstruct the surface mass balance of the "target" simulation, just by looking on the isochronal layers themselves, without a priori knowledge of their evolution through time. The method developed until now allows the reconstruction of the surface mass balance when certain conditions and limitations are made. The future work is focusing on creating a generalized method that will work in more cases.

Presenting author	Andreas Alexander University of Oslo/GEO
Title	Sensing drifters for glacial hydrology flow path measurements
Key words	Glacial hydrology, drifters, flow sensing, glaciology
Abstract	Subglacial hydrology studies are required for a better understanding of glacier dynamics. However, limited access impairs comprehensive surveys of the subglacial environment. Lagrangian drifters present a novel way to measure flow features along glacier channels and might therefore present an answer to the subglacial measurement challenge. We present a new rugged drifter platform, which measures total water pressure, magnetic field strength, linear acceleration and drifter rate of rotation while flowing along a glacial stream. The drifters have been tested on Svalbard glaciers for two consecutive summers. In this presentation, we present how we can use drifters to obtain information from glacial hydrology systems, including water pressures and water velocities. Furthermore, we show how data from the drifter platform might be linked to glacial channel flow features and how we can reconstruct subsurface channel paths.

Presenting author	Tobias Zolles University of Bergen/GEO
Title	The uncertainty of average precipitation forcing for glacier surface mass balance
Key words	surface mass balance, precipitation, downscaling, climatology
Abstract	Although climate undergoes natural variability, it is a common practice that simulations of past ice sheets use climatological instead of transient forcing . We test the sensitivity of the surface mass balance (SMB) of the Greenland ice sheet with the energy balance model BESSI. An ensemble of climate forcings with average values of temperature, precipitation, long and short-wave radiation, and dew point is generated and compared with the fully transient simulation. The climatological forcing leads to an almost 50% larger SMB. Reordering the forcing years in a synthetic transient simulation has a negligible effect of 2% on average Greenland-wide surface mass balance. Mixed forcings of all but one forcing variable transient and the last one climatological and vice versa revealed that the biggest driver for the much larger SMB in the climatological case is the precipitation followed by temperature. To further investigate the effect of averaging precipitation, which changes its nature from event-based to continuous, alternative climatological forcing were created. To retain the event (storm) based nature of precipitation, monthly climatologies were used instead and the sub-monthly variability taken from one of the original transient members.

Presenting author	Kine Onsum Moseid Norwegian Meteorological Institute
Title	Dimming and Brightening in CMIP6 models and experiments
Key words	dimming brightening aerosol forcing history cmip6 ipcc surface energy balance
Abstract	Anthropogenic aerosol emissions have increased considerably over the last century, but climate effects and quantification of the emissions are highly uncertain as one goes back in time. Aerosols suspended in the atmosphere scatter and absorb incoming solar radiation, and thereby alter the Earth's surface energy balance. Previous studies show that Earth system models (ESMs) do not adequately represent surface energy fluxes over the historical era. We investigated global and regional aerosol effects over the time period 1961-2014 by looking at surface downwelling shortwave radiation (SDSR). We used observations from ground stations as well as multiple experiments from eight ESMs participating in CMIP6. Our results show that this subset of models reproduces the observed transient SDSR well in Europe, but poorly in China. The models do not reproduce the observed SDSR evolution in China which is attributed to a change in the emission of sulfur dioxide in this region. Sulfur dioxide is a precursor to sulfate, which is a highly reflective aerosol, and emission of SO$_2$ will therefore be relevant to SDSR. The results from various aerosol emission perturbation experiments from DAMIP, RFMIP and AerChemMIP show that only simulations containing anthropogenic aerosol emissions show dimming, even if the dimming is weaker than observed. We suggest that the discrepancy between modeled and observed SDSR evolution is partly caused by erroneous aerosol and aerosol precursor emission inventories. This is an important finding as it may help interpreting whether ESMs reproduce the historical climate evolution for the right or wrong reason.

Presenting author	Peter Yu Feng Siew University of Bergen/GFI
Title	The relationship between autumn sea ice and wintertime NAO in CMIP models: The role of internal variability
Key words	Arctic-midlatitude teleconnections
Abstract	There is an observed relationship over the satellite period between Arctic sea ice variability in autumn and the North Atlantic Oscillation (NAO) in the following winter. This relationship could help improve seasonal forecasts of the NAO and European climate. Previous studies attempted to identify this ice-NAO relationship in CMIP models, but unfortunately did not find it. Meanwhile, some recent studies report that this ice-NAO relationship is non-stationary and intermittent, which suggests that it is modulated by internal variability. This might explain why the observed ice-NAO relationship is missing in the CMIP models. In this study, we re-evaluate the ice-NAO relationship accounting for the presence of internal variability using CMIP5 and 6 pre-industrial control and transient simulations. The simulations include both standard low-top and high-top (better resolution in the stratosphere) models. We apply a bootstrap sampling technique to the pre-industrial control simulations to assess how the ice-NAO relationship varies under a large range of internal variability. The bootstrap samples exhibit large variability, and only a small number of them (<1%) capture the observed ice-NAO relationship. This is not sensitive to whether the simulations are control (unforced) or transient. Among the bootstrap samples that capture this observed ice-NAO relationship, some features (i.e., polar vortex weakening) of the proposed mechanisms are reproduced. However, these features still exhibit large variability across samples. The large variability of these features within the simulations raises questions about the robustness of the underlying mechanisms and the ability of models to reliably reproduce them.

Presenting author	Francine Janneke Schevenhoven University of Bergen/GFI
Title	Improving weather and climate predictions by training of supermodels
Key words	supermodeling, synchronization, machine learning
Abstract	Given a set of imperfect weather or climate models, predictions can be improved by combining the models dynamically into a so called 'supermodel'. In a supermodel, the models exchange information during the simulation. This is different from the standard multi-model ensemble approach (MME) where the model output is statistically combined after the simulations. Instead the supermodel creates a trajectory closer to observations than any of the imperfect models. The supermodel is a weighted superposition of the states of the imperfect models. To obtain optimal weights, we perform a training with two different methods. The first method updates the weights during training such that the supermodel synchronizes with the truth. The second method is based on an idea called Cross Pollination in Time, where models exchange states during the training. The techniques are applied to different versions of a global coupled atmosphere-ocean-land model. The observations necessary for training come from a version of the same model, but have been perturbed in order to make the training suitable for real-world observations which are noisy and incomplete. Both training methods result in supermodels that outperform the individual models and the MME in short term as well as long term simulations.

Presenting author	YOGESH KUMKAR University of Oslo/GEO
Title	Quantifying regional surface energy responses to forest structural change in Nordic Fennoscandia
Key words	forest structural changes, biogeophysics, climate
Abstract	The surface energy and water fluxes of the vegetated ecosystem largely depend on important structural attributes like leaf area index (LAI) and canopy heights. For forests, management can greatly alter these attributes with resulting consequences for the surface albedo, surface roughness, and evapotranspiration. The sensitivity of surface energy and water budgets to alterations in forest structure is relatively unknown in boreal regions, particularly in Nordic Fennoscandia (Norway, Sweden, and Finland) where the forest management footprint is large. In this study, we perform offline simulations to quantify the sensitivity of surface heat and moisture fluxes to changes in forest composition and structure across daily, seasonal, and annual timescales. For the region on average, it is found that broadleaved deciduous forests cool the surface both annually and in the growing season owed to higher year-round albedo and lower Bowen ratio, yet in some locations the local cooling can be much higher. Moreover, fully developed forests also cool the surface annually in our domain owed to higher evapotranspiration, whereas undeveloped forests warm annually owed to much lower evapotranspiration. If regional forests are ever to be managed for the local climate-regulation services, that they provide, our results are an important first step illuminating the potential adverse impacts or benefits across space and time.

Presenting author	Marius Lambert University of Oslo/GEO
Title	Using dynamic vegetation modelling to explore root water exudation of Norwegian forests during frost droughts
Key words	Fates Cosmo Exudation Drought Arctic Transpiration Water Potential
Abstract	Although the overall living biomass has gone up, there are significant areas across the Arctic that experienced a decrease in vegetation productivity in recent years – a phenomenon, called "Arctic browning". Part of the reason for Arctic browning is a vulnerability to a growing number of extreme weather events associated with climate change. Extreme winter events can initiate icing, loss of frost tolerance, and frost droughts that lead to vegetation damage and death of tissues. While frost droughts are not as well-documented as summer droughts, they are the cause of a considerable proportion of observed damage. Most terrestrial biosphere models represent plant water transport as one single resistance term, or ignore plant hydraulics completely. As a result, leaf transpiration is too strongly regulated by soil water stress. Recent incorporation of much more detailed plant hydraulic modules, based on tissue (root,stem,leaf) level traits, however, opens up the possibility to properly represent frost droughts experienced by plants. In this study, we used the FATES-Hydro, a cohort model of vegetation coexistence and competition, driven by high resolution atmospheric forcing derived from COSMO-REA6, to evaluate how frost droughts impact vegetation mortality in northern Norway over the period 2012-2020. We established a clear link between snow depth and drought intensity. We show that root water exudation at low soil water potentials, rather than leaf transpiration loss at high vapor pressure deficit, explained tissue desiccation during shallow snow covered winters.

Poster Session 1

Presenting author	Maaike Zwier University of Bergen/BIO
Title	Holocene climate variability on sub-Antarctic South Georgia
Key words	Pollen, vegetation, paleoclimate, Southern Hemisphere Westerlies, Sub-Antarctic, Holocene
Abstract	The Southern Hemisphere Westerly Winds play a major role in the global climate system. They drive circulation in the Southern Ocean which affects the upwelling of carbon-rich deep water and the oceans ability to take up atmospheric CO2. Due to the limited amount of land mass on the Southern Hemisphere, sub-Antarctic islands are invaluable for studying long term climate variability in this region. They provide valuable insights into both local and regional surface climate conditions. South Georgia is positioned in the core belt of the Southern Hemisphere Westerly Winds and located at the boundary of the Antarctic Circumpolar Current and Antarctic Polar Frontal Zone. Its position is therefore ideal to capture changes in these major atmospheric and oceanic circulation systems. A pollen record from Lake Diamond provides detailed reconstructions of vegetation and climate on South Georgia for the last ~9900 years. The behavior of the Westerlies acts as a first-order control on local vegetation change by impacting temperature conditions and moisture availability. Changes in relative pollen abundance of native taxa occupying either upland (cold) or lowland (warm) environments are used to infer local climatic variation. In addition, Westerly Wind strength and position governs the influx of long-distance transported pollen from South America, Africa and New Zealand. On South Georgia we find that the non-native pollen from several taxa increase in abundance in periods of local cooler and wetter climate conditions.

Presenting author	Kai-Uwe Eiselt University of Tromsø
Title	Time Dependence of Climate Sensitivity
Key words	climate sensitivity, feedback, CMIP, radiative kernel, Gregory method
Abstract	Climate sensitivity is typically defined as the global mean surface temperature change in response to a forcing due to a doubling of the CO-2 concentration in the atmosphere. An important factor influencing climate sensitivity are feedbacks of the climate system that arise due to the temperature change. To investigate these feedbacks complex numerical climate models are required. Research on climate sensitivity has revealed that the most commonly used methods to estimate a value for this metric yield results that depend on the length of the time period the climate system had to respond to the forcing. As of yet there is no consensus on what causes this time dependence of climate sensitivity, although most recent research suggests an interplay of feedbacks and a change of the strength of individual feedbacks over time as major contributing factors. We employ the Gregory method to investigate total model feedback and its change as well the radiative kernel method to derive feedback decompositions for a range of members of versions 5 and 6 of the Coupled Model Intercomparison Project (CMIP) in the abrupt-4xCO2 experiment. Large differences in estimated climate sensitivity as well as time dependent change of climate sensitivity exist between the individual members. The most pronounced differences between individual model feedbacks are evident in cloud feedback and models with high climate sensitivity have comparatively large positive cloud feedback, while models with low climate sensitivity have low positive or even negative cloud feedback.

Presenting author	Nikolai Figenschau University of Tromsø
Title	Seasonal variability in Arctic ship traffic
Key words	Arctic shipping sea-ice pollution atmosphere
Abstract	Arctic shipping is a major local contributor to air pollution in the Arctic and is expected to increase significantly in the future. The increase is linked with a declining Arctic sea ice, which expose previously ice covered areas of the Arctic Ocean and make exploration without icebreaker support possible. However, the relation between sea ice and ship traffic and its effect on atmospheric pollution is poorly understood. Therefore, we want to assess the impact of sea ice on ship traffic and the associated pollution. We examined and compared the spatial distribution of sea ice with ship traffic and associated emissions of atmospheric pollutants from 2013. We applied simple statistical analysis for quantifying and illustrating seasonal patterns of multivariate data in two-dimensional statistical slices. Both ship traffic and the associated emissions exhibit an inverse relationship to sea ice extent, as they increase with a declining sea ice extent during summer melt season (June – late September). During winter, ship traffic is limited to the Norwegian coast and the westernmost part of Russia (Murmansk). During summer, an eastward migration of ship traffic occurs (along the Northern Sea Route). Additionally, distributional analysis show that areas with dense ship traffic (Norwegian coast) has a much lower average emission rate than low-density areas (Russian Border and west/southwest of Svalbard). These findings support that variability in ship traffic and the associated emissions of air pollution are strongly associated to sea ice extent. They also suggest that seasonal shipping emits larger amounts of pollutants.

Presenting author	Julius Lauber Norwegian Polar Institute
Title	Oceanic and Atmospheric Mechanisms Driving the Melting of Fimbul Ice Shelf
Key words	ice shelf, Antarctica, physical oceanography, observations
Abstract	The Antarctic Ice Sheet represents a key component of the global climate system, providing huge amounts of freshwater that could possibly end up in the ocean in the future and thus contribute to global sea level rise. Inflows of warm water masses into the cavities (the oceans below the ice shelves) are known to drive a significant amount of basal melting of the Antarctic ice shelves. However, the mechanisms controlling the behavior of these warm inflows are not exactly known yet. An understanding of these controls is important to predict the melting for future climate scenarios. 9 years of observations of temperature and velocity from three moorings below Fimbul Ice Shelf (FIS), East Antarctica, are presented. There, an inflow of warm water is only periodic, leading to a reduced melting and a mass balance close to zero. The timing of the warm inflow events is found to be connected to negative anomalies of sea ice concentration around FIS. A possible explanation is that the resulting increased amount of freshwater relaxes the front which usually separates the cold water below the ice shelf from the warm water offshore. Additional connections with large-scale atmospheric patterns are expected, which is still subject of investigation.

Presenting author	Franziska Hellmuth University of Oslo/GEO
Title	Linking cloud phase to surface snowfall through remote sensing, in-situ measurements and climate modelling
Key words	snowfall, clouds, remote sensing, in-situ observations, climate modelling
Abstract	Cloud feedbacks are the major contributors to the spread in climate sensitivity simulated in global climate models (GCMs) [Flato et al., 2013]. GCMs underestimate the ice water path and overestimate the liquid water path when compared to satellite measurements, which is likely related to the parametrisation of ice nucleation and growth processes. The objective of this PhD is to improve the representation of different cloud regimes and related snowfall in GCMs, especially at high latitudes. In this aim, a combination of satellite and ground-based remote sensing, in-situ measurements and climate model simulations will be used. By doing so we wish to improve the understanding of how cloud phase influences snowfall in the present climate, improve the representation of this link in the Norwegian Earth System Model (NorESM2), and ultimately predict how cloud phase and snowfall will change in the future, with important implications for example for the modelling of glaciers and ice sheets. The goal is to use state-of-the-art ground-based remote sensing and in-situ measurements of different mixed-phase cloud regimes, during diverse snowfall events at different sites, as case studies, to gain a better understanding of the microphysical processes that are critical to represent well in NorESM2.

Presenting author	Jan Markus Diezel University of Bergen/GFI
Title	Boundary layer characterization for airborne wind energy applications – preliminary findings
Key words	atmospheric boundary layer, lidar, wind energy
Abstract	Airborne Wind Energy Systems (AWES) are a set of technologies that use flying tethered objects to produce power from the wind. With current test flights typically taking place at heights between 500 m and 700 m, AWES reach considerably higher than conventional wind turbines. It is commonly stated that winds higher up in the atmospheric boundary layer are stronger and more consistent. This statement is investigated and quantified through the use of Lidar data from several measurement locations in Norway. Testing this statement is highly relevant to AWES, as the quality of the wind is a major factor determining the reliability of power production through AWES in comparison to conventional turbines. The presentation will contain two parts. For the main part, already existing wind profile data sets from Lidars will be used to show some first analysis results. The second part introduces a new measurement campaign with a unique set-up of Lidar measurements in parallel to AWES test flights. This measurement campaign is scheduled to take place in southern Norway for one year starting from October 2020. The goal of the presentation is to introduce the relevant concepts used by AWES, to discuss preliminary findings about wind profiles in the upper atmospheric boundary layer and provide a platform to discuss further research questions and methods on this topic.

Presenting author	Eirik Ballo University of Oslo/CEED
Title	Using CT scans to count varves in lake sediments. Application to Lake Sagtjernet, southeastern Norway
Key words	lake sediments, varve chronology, varve coutning, CT, age-depth model
Abstract	Annually laminated sediments, also called varves, are valuable natural archives to reconstruct past environments and climate. Until now the most common and reliable procedure to count varves has been to produce overlapping thin sections of the entire sediment sequence and counting in the microscope, a process that can take months to complete. We present a new and faster method to count varves using CT scans. This non-destructive method is not only faster, it also provides a 3D view of the varve boundaries — a significant improvement compared to the 2D view from conventional thin section counting. We used the sediments of Lake Sagtjernet to develop this method. Oxygen and temperature measurements from the lake combined with microfacies analyses show that the varves are likely formed by cyclical Fe precipitation during the late fall mixing of the water column. Varve counting on CT scans resulted in a 5000-year chronology which we compared to an independent chronology (based on 11 14C dates and radionuclide analyses). Our preliminary results show that there is a good correspondence between the two chronologies, especially for the top 3 meters of the total 5.5 meter sediment sequence. Ultimately, this new varve chronology of Lake Sagtjernet provides a basis for the reconstruction of past climate with an annual resolution. This can improve our understanding of the interactions between climate and human society in Norway.

Presenting author	Britta Schäfer University of Oslo/GEO
Title	Lidar Observations of Mixed-Phase and Ice Clouds in Northern Norway
Key words	Clouds, lidar, mixed-phase
Abstract	Mixed-phase clouds consist of ice crystals and supercooled water droplets. Their radiative properties are essential for their impact on climate and strongly depend on structure and composition of the cloud. My PhD project aims to get a better understanding of horizontal structures in these clouds and the evolution of cloud properties under different background conditions. I apply both an observational and a theoretical (small-scale modeling) approach in order to increase the physical process understanding. Currently, I focus on observational data from high latitudes, using groundbased and satellite lidar data from Northern Norway. Both case studies and a statistical overview of local cloud properties will be presented.

Presenting author	Johannes Lutzmann University of Bergen/GFI
Title	Lifecycle of fronts of mid-latitude cyclones and their role in maintaining extratropical storm tracks
Key words	storm tracks, fronts, mid-latitude cyclones
Abstract	In recent years, a number of publications demonstrated that latent heating within mid-latitude cyclones is a source of baroclinicity, balancing the meridional transport of heat and sustaining storm tracks. This latent heating, mainly occurring in the frontal systems of a cyclone, persists beyond the lifecycle of the cyclone in the case of strong trailing cold fronts and thus leads to secondary cyclogenesis and cyclone clustering, which is often associated with severe weather events causing considerable damage. Therefore, understanding the conditions in which fronts act in this way is important for understanding and correctly forecasting such events. In our project, we aim to document and classify the behavior and lifecycle of fronts with respect to the production of baroclinicity and their sensitivity to forcing factors, in particular moist adiabatic heating . We will apply established diagnostic tools to reanalysis data covering storm tracks and cyclone clustering events to detect and classify frontal lifecycles. Additionally we aim to gain a mechanistic understanding through idealized and realistic meso-scale simulations of selected events with the Weather Research and Forecasting (WRF) Model. We will present an overview of the scientific background, the motivation, and the planned methods of our project.

Presenting author	Kjersti Konstali University of Bergen/GFI
Title	Observed changes in precipitation in Norway 1900-2019
Key words	precipitation, norway
Abstract	Annual mean precipitation has increased by more than 15% in Norway during the last century and is expected to increaser further. However, the observed trends to not match the trends observed in neither the reanalysis products nor climate models. This calls to better understand and determine the most important physical processes that has driven this increase in precipitation. The variability in precipitation is to a large extent driven by the variability in precipitation in Western Norway, and hence, the annual mean precipitation is very sensitive to changes in cyclone activity and cyclone tracks in the North Atlantic. To try to explain the precipitation increase, we combine reanalysis with an observational record, spanning from 1900-2019 of precipitation in Norway.

Presenting author	Vår Iren Hjorth Dundas University of Bergen/GFI
Title	The importance of storm events for on-shelf heat transport in the Filchner Trough
Key words	Weddell Sea, metroms, impact of storms
Abstract	A year-long mooring time series indicate that storm events on a weak background wind field is a driver of warm inflow into the Filchner Trough (Darelius et al., 2016). Studies of nearby moorings do not show the same relation (Ryan et al., 2017). We want to investigate this further by first examining the effect of adapting an existing idealized model (Daae et al., 2017) to include periods of short-lasting, but sudden and strong winds. Then, we will do a search for the conditions which the idealized model indicate are favorable for far-reaching warm inflow in a high-resolution regional model. A search for periods of similarly favorable conditions in a newly recovered mooring array could add confidence to this study, if such periods exist. To achieve a realistic setup of the idealized model, we do a statistical analysis of winds and storm events using reanalysis data from ERA 5. We hypothesize that storms in succession may lead to the same situation as persistent strong winds, where a sharp ASF impedes heat transport into the trough. Questions to answer therefore include where the limit goes between storms that may lead to increased on-shelf heat transport, and when the inflow is blocked, as well as the importance of the background hydrographic setting for the effect of such storm events. Another, possibly quantifiable, question is the relative importance of storm events versus surface layer stratification and the upper layer eddy overturning cell described by Daae et al. (2017).

Presenting author	Trygve Halsne University of Bergen/GFI
Title	Wave-current interaction in strong tidal currents
Key words	waves, currents, tides
Abstract	From the first in situ data set in the Lofoten Maelstrom, we present strong interaction processes between the ocean current and the waves. The results aligns with the theory of conservation of wave energy.

Presenting author	Xabier Davila Rodriguez University of Bergen/GFI
Title	How is the ocean anthropogenic carbon reservoir filled?
Key words	Carbon, Transport, Anthopogenic, Circulation, Observations, Reservoir
Abstract	About a quarter of the anthropogenic fossil fuel CO2 emissions are absorbed by the ocean. The rate limiting step for this uptake is the transport of the anthropogenic carbon (Cant) from the surface ocean where it is absorbed, to the deep where it is stored on a long term basis. While it is generally known that regions where dense waters form and sink from the surface to the deep ocean are important for the vertical carbon transport, the exact magnitude of these fluxes in different regions are uncertain. Here we use a transport matrix to reconstruct the pathways for Cant into the deep ocean. The time-evolving surface boundary condition for the Cant was determined by using surface pCO2 from the Norwegian Earth System model and climatological distributions. The transport matrix connects 2806 possible surface sources to 74064 ocean interior grid cells assuming steady state circulation. We show that around one third of the ocean's annual uptake is stored in the deep ocean long-term reservoir below 1000 m. Although the Southern Ocean absorbs a large fraction of the ocean Cant, most of this is stored in the main thermocline due to the shallow overturning circulation. The Labrador Sea is the main contributors of the Cant injection to waters below 1000 m.

Presenting author	Carmen Braun University of Tromsø
Title	Lithostratigraphic studies for palaeoenvironmental reconstructions in the western Fram Strait – preliminary results
Key words	palaeoenvironment, offshore, Greenland, Fram Strait
Abstract	Marine sediment cores are an invaluable tool for reconstructing palaeoenvironments. While a large number of sediment cores have been retrieved from the Fram Strait and the Greenland Sea, fewer have been taken from western Fram Strait. The glacial-interglacial history of those areas is therefore less well constrained. Two gravity cores recovered from the western Fram Strait are analysed to reconstruct the local palaeoenvironment using lithostratigraphic methods. The preliminary grain size analyses, as well as other data from the cores, provide insight into the sedimentary processes and bottom-currents, as well as the history of ice-rafting. Based on preliminary age correlations, these results are expected to reflect several marine isotope stages.

Presenting author	Coline BOUCHAYER University of Oslo/GEO
Title	Modeling transient velocity variations in glaciers
Key words	modeling, rate-and-state friction law, soft-bedded glaciers, fast-flowing
Abstract	Climate change will drastically affect dynamical processes such as calving of fast-flow glaciers that will increase ice discharge into the ocean. Fast glacier flow is mainly controlled by the sliding of the ice on its bed, involving complex sliding and shearing processes in the presence of sediments, water and varying thermal conditions at or below the melting point. Although basal-slip rules have been the subject of long-term theoretical debates, they are difficult to test empirically because of the lack of long measurements due to the difficult access to ice-bed interface. Correct formulations of a slip relation are essential for predicting the overall motion of a glacier. As ice sheet and glacier models become more sophisticated through improved computational techniques, the continued use of empirical, and in some cases largely untested, constitutive equations may lead to progressively larger relative sources of error. The rate-and-state friction law is well known in fault and earthquakes mechanics but it is not used so far to explain friction at the base of the glacier. Theoretical developments and numerical modeling will be used during my PhD to develop a new framework based on the rate-and-state friction law to trigger velocity changes on soft-bedded polythermal glaciers.

Presenting author	Paul Halas University of Bergen/GEO
Title	Remote sensed velocities of Greenland land terminating glaciers
Key words	Greenland remote sensing velocities land-terminating
Abstract	As depicted in the last IPCC report, ice losses from the Greenland Ice sheet (GIS) have been increasing in the last two decades, leading to a larger contribution to the global sea level rise. Mass from the Greenland Ice Sheet can be lost both through decrease in surface mass balance and through an increase in ice flow directly discharging ice to ocean. This study focuses on dynamic losses, assessing the surface velocities variations of land-terminating glaciers at both annual and seasonal timescale. Previous studies showed decreasing velocities for the land-terminating glaciers in Southwest Greenland, in a context of increased melting (Tedstone et al., 2015, Sole et al., 2013). But a more recent study noted through additional observations that the slowdown is not confirmed outside Tedstone area (Joughin et al., 2018). In order to find out whether the land-terminating glaciers of Greenland are undergoing an acceleration, our project is taking advantage of recent ESA Sentinel 2 satellites, which provide relatively high temporal and spatial resolution data since 2015, allowing observation of sub-seasonal velocity fluctuations (Mouginot et al., 2017, Fahnestock et al., 2016). Despite the better resolutions, assessing glaciers velocities is still challenging because of the dense cloud cover in the area and the small number of features that can be tracked by our velocity algorithm.

Presenting author	Elin Cecilie RIstorp Aas University of Oslo/GEO
Title	The role of soil microbes in the climate system
Key words	soil,carbon, microbes, decomposition,climate change
Abstract	One of the most important controls on the exchange of carbon between soils and the atmosphere are the microbial activity that happens below ground. During plant litter decomposition, bacteria and fungi both store carbon as biomass, and respire CO2 back into the atmosphere. In addition, symbiotic relationships between plants and fungi are important for the flow of carbon and nutrients between the aboveground and below-ground world. Changes in abiotic factors like temperature and moisture will likely affect the rate and efficiency of these soil processes, which again may affect the rate of carbon to and from the atmosphere. Representation of litter decomposition in ESMs have traditionally been very simplified, something that has introduced large uncertainties in the models. An emerging approach to tackle these challenges is to represent microbial soil processes explicitly in the models. Following this approach, we have built a process based module that represent the carbon and nitrogen fluxes during soil decomposition, from aboveground litter to soil organic matter (SOM). The role of saprotrophs (decomposers) and mycorrhizal fungi (in symbioses with host plants) is explicitly represented with separate carbon and nitrogen pools with associated fluxes. The long-term objective is to develop an improved module that can be used to represent soil processes in ESMs, and thereby reduce the uncertainty connected to the exchange of carbon between land and atmosphere. Preliminary results showing the potential and challenges of this kind of modeling approach will be presented.

Poster Session 2

Presenting author	Danielle Grant NORCE
Title	Reconstructing Sea Ice in the Arctic through sedaDNA
Key words	sedaDNA, Arctic, Sea-Ice, paleoceanography, molecular ecology
Abstract	The rapid decline of Arctic sea ice in recent decades has been touted as the canary in the coal mine for the impacts of anthropogenic driven climate change. Modeling projections suggest that within the next three decades the Arctic may be sea ice-free in the summer (Holland, S.J., et al. 2007; IPCC, 2019). Sea ice is considered a critical component of the climate system with both local and global impacts (Li, C. & Born, A., 2019). Despite the critical role of sea ice, there are significant knowledge gaps regarding natural sea ice variability. These gaps limit our ability to accurately predict and prepare for the changing Arctic. To address the information gap, our group AGENSI: A Genetic View into Past Sea Ice Variability in the Arctic, will develop multi-proxy sea ice reconstructions at key locations (eg. Labrador Sea). The sea ice reconstructions will utilize microfossil assemblages, biomarker IP25, and sedimentary ancient DNA (sedaDNA) isolated from Arctic marine piston cores. SedaDNA is an emerging tool for sea ice reconstructions, which can provide qualitative and quantitative information for varying sea ice conditions (De Schepper, S., et al, 2019). Qualitative data is generated through sedaDNA metabarcoding, which reconstructs the full community of past sea ice algae/diatoms/dinoflagellates. The quantitative approach targets indicator species specific to different sea ice conditions through digital droplet PCR (ddPCR). Overall, the multi-proxy approach ensures robust paleorecords. The proposed sea ice reconstruction will provide context for natural sea ice variability throughout the last ~130,000 years.

Presenting author	Kristine Steinsland NORCE
Title	The role of sea ice in Late Quaternary Nordic Seas paleoceanography
Key words	sea ice, biomarkers, dinoflagellate cysts, paleoceanography
Abstract	Model simulations predict that a summer without sea ice may be a reality within the next three decades. Sea ice provides a strong feedback in the climate system due to its high impact on surface albedo, atmosphere-ocean heat and moisture exchange, deep water formation and ocean circulation. In addition, studies have demonstrated the importance of sea ice for modulating the strength of the Thermohaline circulation (THC) through glacials, and even interglacials. Despite the fundamental relevance of sea ice our understanding of the role that it plays in ocean circulation, and ultimately climate, remains incomplete. To assess the role of sea ice in the climate system and its relationship with THC we can reconstruct the natural variability of sea ice and sea surface conditions from the paleorecord. Here, we utilize biomarkers (IP25, sterols) and dinoflagellate cyst assemblages spanning the early Holocene through the last interglacial, targeting stadial-interstadial and glacial-interglacial transitions. Reconstructions will be based on a sediment core from the Fram Strait, which could capture changes of inflowing Atlantic water into the Arctic. A comparison will be made to new data from the Eirik Drift, a key location for deep water convection which also records influence of Arctic water into the North Atlantic. Better sea ice reconstructions allow for an assessment on its sensitivity to climate forcing, its role in the climate system and in THC variations. This is key in order to more accurately predict the future of THC- and climate- stability in a future summer, sea ice-free Arctic.

Presenting author	Jakob Dörr University of Bergen/GFI
Title	Present and future drivers of winter Arctic winter sea-ice variability
Key words	Arctic, sea ice, winter, ocean heat transport, variability, large ensemble
Abstract	Over the last decades, the observed interannual variability and trends in the Arctic sea-ice cover in winter have been primarily driven by variable ocean heat transport into the Arctic. The loss of winter Arctic sea ice is projected to accelerate, especially after the Arctic becomes ice-free in summer. As the winter sea-ice cover decreases and the sea ice retreats towards the Arctic Ocean, the question arises how the influence of the ocean heat transport will change, and to which extent other drivers, such as the atmospheric circulation or river runoff into the Arctic Ocean, will become important. Using simulations of the Community Earth System Model Large Ensemble (CESM-LENS), I analyze and quantify the present and future influence of the different potential drivers on the variability and trends of the Arctic sea ice cover during winter. Furthermore, I compare the regional influence of the different drivers.

Presenting author	Herman Fuglestvedt University of Oslo/GEO
Title	Modelling the radiative forcing of high-latitude volcanic eruptions
Key words	volcanic eruptions climate earth system modelling
Abstract	Large volcanic eruptions was the major driver of natural climate variability during the last millennium and continue to introduce annual to decadal climate variability in scenarios of the future. The radiative forcing associated with a volcanic eruption depends on a wide range of its properties, such as the eruption location, height, chemical composition, duration, as well as the season, climate state, and synoptic situation that it occurs in. While previous research has mainly focused on tropical eruptions, which are commonly believed to have a stronger impact on surface climate, the sensitivities to the above properties are to a great extent unexplored when it comes to high-latitude eruptions. Moreover, proxy records show that the climate response after high-latitude eruptions have been significantly different from that of tropical ones. We will conduct a systematic study of the climate response to high-latitude eruptions with the earth system model CESM2-WACCM6. In addition to evaluating chemical/microphysical and dynamical effects, special focus will be on atmospheric circulation changes that diverge from those of tropical eruptions.

Presenting author	Leilane Passos University of Bergen/GFI
Title	Prediction skill in the Subpolar North Atlantic and Nordic Seas in the Norwegian Climate Prediction Model (NorCPM)
Key words	Decadal predictability; Nordic Seas; Subpolar North Atlantic; NorCPM
Abstract	Temperature and salinity anomalies in the subpolar North Atlantic (SPNA) and Nordic Seas are considered important sources for predictability of Arctic ocean heat content, sea ice, and air-sea interaction on interannual to decadal time scales. In this work, the ability to predict the ocean state in the SPNA and Nordic Seas is investigated using different versions of the Norwegian Climate Prediction Model (NorCPM). We specifically compare one version with data assimilation of only sea surface temperature with another version with assimilation of both sea surface temperature and sub-surface hydrographic profiles. Preliminary results show an improvement of prediction skill when the data assimilation is applied both at the surface and in the subsurface ocean. For this version, the ensemble mean anomaly correlation coefficient for winter SST is 0.7 up to 3 years lead time over the time period 1983-2009 in the eastern part of the Nordic Seas. In the SPNA, the correlation is 0.7 in large areas up to 7 years lead time. Additional analysis will shed further light on prediction skill in the SPNA and the Nordic Seas – in particular on the inflow region to the Nordic Seas – and the role of different initialization methods.

Presenting author	Natacha Galmiche University of Bergen/GFI
Title	Exploring Multimodality in Weather Prediction using topological data analysis and machine learning
Key words	multimodality, weather forecasting, topological data analysis, machine learning, ensemble methods
Abstract	The common practice in weather and climate prediction is to use ensemble methods. Multiple forecasts (or members) are produced and result in a probability distribution. These probability distributions may come in very different shapes and qualitatively summarizing them to provide a comprehensive forecast is not trivial, especially in the case of multimodality with distinct likely outcomes. Currently used methods to interpret these ensemble-based data might discard some crucial information. Indeed detecting and tracking accurately weather features such as cyclones over time and across ensemble members is challenging and is even more complex if multiple trajectories of a given feature are likely. In this project, we aim at combining previously developed algorithm in meteorology with topological data analysis and machine learning techniques to improve our understanding of ensemble-based weather data.

Presenting author	Christiane Duscha University of Bergen/GFI
Title	A ship-based and multi-sensor approach to characterise coherent boundary-layer structures during a marine cold air outbreak
Key words	convective boundary layer, organised convection, marine cold air outbreak
Abstract	Turbulent heat fluxes reduce instabilities formed due to advection of cold air over a warm ocean surface, often referred to as marine cold air outbreaks (CAO). Organised convection, namely coherent structures, contributes an essential part to these compensating turbulent fluxes. Past observations obtained from aircraft identified these coherent structures, in particular during marine CAO conditions. Yet, these observations are limited in temporal resolution and to an one dimensional set of supplementary atmospheric variables. In this study, we evaluate a new ship-based approach for its potential to identify coherent structures. Additionally, we use observations simultaneously obtained by a multi-sensor setup to identify relevant boundary layer processes. We finally evaluate the interaction between these processes and the coherent structures identified with the new ship-based approach. We test this new ship-based and multi-sensor approach during a CAO case study. The new approach achieves to identify coherent structures. In particular, we successfully identify small scale cellular structures (~1km). The strongest interaction of these structures was found with boundary layer clouds. The horizontal extend of these structures strongly depended on the cloud base height. Continuous precipitation suppressed the development of the coherent structures, while convective showers even introduced artificial coherent structure detection. Increased buoyant forcing shifted the distribution of the small scale structures towards even smaller sizes. This caused an increased scale separation between the small scale structures and the more stationary mesoscale structures. In conclusion, we characterised coherent structures during a marine CAO, specifically at a scale that previous observational approaches neglect.

Presenting author	Marvin Kähnert University of Bergen/GFI
Title	The interplay of physical processes in an NWP model - A CAO case study with AROME-Arctic tendencies
Key words	model tendencies, paramterisations, boundary layer, CAO, NWP
Abstract	Cold air outbreaks critically rely on the interplay of multiple physical processes that suffer from poor accuracy in atmospheric models. However, this interplay has not yet been quantified even though it has been recognised to contribute to forecast uncertainty. By implementing single physical tendency output into the operational NWP model AROME-Arctic we quantify the contributions of parameterised physical processes during an intense CAO. We identify controlling factors for the activity of single parameterised processes and assess their interactions. Further, we demonstrate the sensitivity of these interactions to an increase or decrease of the shallow convection scheme. Shallow convection, turbulence and microphysics are the governing processes during the event. Model intern boundary layer types are the decisive factors for controlling the activity of these processes. A strong compensation between the turbulence and shallow convection scheme is evident. The resulting residuum between these two processes is likewise compensated by the contribution of the microphysics scheme. This residuum remains nearly unchanged between the sensitivity experiments, even though single tendency contributions differ by up to an order of magnitude. We only find a change in the residuum when a dynamical response of the model is triggered by the modifications. Such a response can be identified by the presence or absence of grid scale vertical updrafts and downdrafts in the model.

Presenting author	Mathias Tollinger University of Tromsø
Title	Using synthetic aperture radar in relation to polar lows
Key words	synthetic aperture radar, polar low, wind retrieval, remote sensing
Abstract	High resolution sea surface observations from the space born Sentinel-1 synthetic aperture radar (SAR) instrument represent a sorely underused resource for meteorological applications in polar regions. The radar signal return depends on the sea surface roughness exerted by the surface wind field. Therefore, meteorological wind phenomena imprint their signature in SAR observations. The ever increasing spacial and temporal coverage of SAR observations in polar regions calls for the development of application strategies that exploit this valuable resource. Polar low pressure systems are short lived, intense, maritime mesoscale cyclones typical of polar regions that pose a challenge with respect to weather forecasting. Here we asses the potential range of applications for SAR observations with respect to the understanding and forecasting of polar low pressure systems by a number of case studies. The performance of current observational systems and operational numerical modeling systems in detecting and predicting polar lows is explored. Potential ways of assimilating information from SAR observations into numerical weather models are probed.

Presenting author	Gaurav Madan University of Oslo/GEO
Title	Contribution of surface flux and ocean heat transport convergence to the inter-annual heat content variability of the Labrador Sea
Key words	Labrador Sea, Subpolar North Atlantic, Newfoundland Basin, Ocean Heat Convergence
Abstract	The heat content and convergence of the heat flux transport (CHFT) in the ocean region 65W-40W, 45N-65N is studied based on in-situ observations of ocean temperature and the reanalysis of surface flux for the period from 1993 to 2018. This region includes the Labrador Sea, the area of North Atlantic Current, and Newfoundland Basin. The CHFT is computed from the equations of the tendency of heat contents for the surface (0-150 m depth), intermediate (150-2000 m depth), and deep (below 2000 m) layers and the whole ocean column. The highest interannual variability of CHFT is observed in the regions of the Newfoundland Basin and North Atlantic Current. The CHFT in the first region is influenced by the influx of sea-ice from the Northern Labrador Sea. The interannual variability of the CHFT in the second region represents the year-to-year change in the contribution of the ocean transport to the heat budget by the extension of Gulf Stream in the Subpolar North Atlantic. The CHFT in the central, eastern, northwestern, and northeastern sub-regions of the Labrador Sea were found to be highly correlated ($r>0.7$). There is a very weak correlation between the CHFT in these regions and the CHFT in the Newfoundland Basin and North Atlantic Current.

Presenting author	Anna-Marie Strehl University of Bergen/GFI
Title	Freshwater and Heat Content Variability in the North Atlantic Subpolar Gyre
Key words	subpolar gyre, freshwater, heat
Abstract	The subpolar North Atlantic is a region of intense air-sea interaction and one of the few places on Earth where deep water is formed, connecting the deep ocean with the atmosphere. In this presentation, we will investigate the hydrographic variability in the North Atlantic subpolar gyre with ECCO reanalysis data for the period 1992-2017 and, specifically, compare the causes of the heat and freshwater variability. We find that the freshwater and heat content variability can be separated into two regimes, where the first regime from 1996 to 2007 is characterised by a salinisation and warming at a mean rate of ~$-4*10^11 m^3/year$ and ~ $3*10^20 J/year$, respectively, which is attributed to the advection of heat and salt from the North Atlantic Current. In the second regime, this behaviour is reversed, and we identify a cooling and freshening, reflecting an increased advection of polar water. The change from the first to the second regime is associated with a freshwater gain of ~$1*10^11 m^3/year$ and a heat loss of ~$-4*10^20 J/year$ starting in 2007 and lasting until 2017. Closer inspection of the advective and diffusive fluxes shows that advection along the boundary currents is the main source of changes for both the freshwater and heat content variability. While the heat content variability is mainly driven by the North Atlantic Current, the freshwater content is also strongly impacted by eddy turbulence in the mixed layer, which contributes to the exchange of fresh, polar water with the interior subpolar gyre.

Presenting author	Evelien van Dijk University of Oslo/GEO
Title	Was there a long lasting cooling over Europe in the mid-6th century?
Key words	paleoclimate, volcanism, model-proxy comparison, climate modeling
Abstract	Here we present analyses of the impact of a series of volcanic eruptions in the mid-6th century on the atmospheric circulation and surface climate, with a focus on the North Atlantic and Europe, using climate model simulations, new and available paleo proxies. The middle of the 6th century is an outstanding period marked by an unusual cold period that lasted several years to decades, due to the 536/540 CE double eruption event. Evidence from multiple tree ring records from the Alps to the Altai Mountains in Central Asia demonstrate a centennial cooling lasting from 536 up to 660 CE. In this period, glaciers advanced strongly throughout Eurasia which has motivated researchers to refer to the period as the "Late Antique Little Ice Age (LALIA)". Ensemble simulations with the Max Planck Institute Earth System Model (MPI-ESM) have been used to show that the double eruption led to a global decrease in temperature and an increase in Arctic sea-ice for at least a decade, possibly initiating the long lasting cold period until ~660 CE. This study analyzes the model output from these and new MPI-ESM simulations for the effects on atmospheric circulation, North Atlantic Oscillation/Northern Annular Mode variations, and the ocean/sea-ice response, as well as to get a sense of what the short- and long term effects are of these different forcings on the climate, and if it is possible to initiate a long lasting cooling with (a set of) volcanic eruptions.

Presenting author	Ashneel Chandra University of Bergen/GFI
Title	Intraseasonal variability of ocean heat content
Key words	ocean heat content, intraseasonal variability, Madden-Julian Oscillation, ENSO
Abstract	Intraseasonal variability of ocean heat content (OHC) and 20°C isotherm depth (D20) is investigated in the equatorial Pacific Ocean using HYCOM reanalysis product. The OHC and D20 data are bandbass filtered using a 10 to 90 day butterworth filter. The RMM1 and RMM2 indices associated with the Madden-Julian Oscillation is used as an index of intraseasonal variability. The intraseasonal D20 shows signatures of equatorial Kelvin waves which are associated with atmospheric forcing as revealed by NCEP zonal wind anomalies. The intraseasonal D20 is then used to investigate the 2009 El Niño event. Intraseasonal Kelvin waves are seen to play a part in the onset of the 2009 El Niño. Intraseasonal OHC anomalies are seen to propagate from the eastern to the central Pacific leading to the El Niño event in late 2009.

Presenting author	Vårin Trælvik Eilertsen University of Tromsø
Title	Palaeo-environments in the northern Barents Sea, from the last glacial to the present — preliminary results
Key words	Barents sea ice sheet, glacial landforms, sediments.
Abstract	During the last glacial maximum, the Svalbard-Barents Sea Ice Sheet extended to the shelf break north of Svalbard. The activity of grounded ice resulted in the formation of glacial landforms such as streamlined ridges/grooves, grounding zone wedges and meltwater channels. These landforms characterise the troughs in the northern Barents Sea. The activity of grounded ice also resulted in deposition of muddy glacigenic diamicts. Overlying the diamicts are a cover of proximal glaciomarine deposits capped by Holocene marine muds. Analysing the sediments and investigating the landforms provide information of the dynamics of the glacial retreat and past ice flow directions. The purpose of this study is to reconstruct the glacial dynamics of the ice sheet on the northern part of the Barents Sea shelf during the final phase of the last glacial, as well as to reconstruct the depositional environment from the last glacial until the present. A total of eight gravity cores (1.15 to 5.05 m long) were retrieved from water depths of ca. 250-550 m in the Olga Strait, an unnamed Strait south of Kvitøya and the Kvitøya Trough. High-resolution sub-bottom profiler data and swath bathymetry were acquired with RV Kronprins Haakon during the Nansen Legacy paleo cruise. Preliminary results from multi-proxy analyses of the sediment cores including physical properties, grain size distribution, lithostratigraphy and XRF will be presented.

Presenting author	Maaike Weerdesteijn University of Oslo/CEED
Title	Developing an open-source 3D glacial isostatic adjustment modeling code using ASPECT
Key words	glacial isostatic adjustment, Earth modeling, code development
Abstract	Models of Glacial Isostatic Adjustment (GIA) processes are useful because they help us understand landscape evolution in past and current glaciated regions. Such models are sensitive to ice and ocean loading as well as to Earth material properties, such as viscosity. Many current GIA models assume radially-symmetric (layered) viscosity structures, but viscosity may vary laterally and these variations can have large effects on GIA modeling outputs. Here we present the potential of using ASPECT, an open-source finite element mantle-convection code that can handle lateral viscosity variations, for GIA modeling applications. ASPECT has the advantage of adaptive mesh refinement, making it computationally efficient, especially for problems such as GIA with large variations in strain rates. Furthermore, ASPECT is open-source, as will be the GIA extension, making it a valuable future tool for the GIA community. We benchmark the code for free surface traction on a homogeneous and a layered viscoelastic 3D box model with analytical solutions of a loaded infinite viscoelastic half-space, and a viscoelastic half-space overlain by a viscoelastic layer. We also show the capability of using lateral viscosity variations, and how it affects the free surface deformation. We show the possibilities, capabilities, and potential of ASPECT for GIA modeling. We will further develop the code with the sea level equation and an ocean basin, and will explore ASPECT's current capability of using time-varying distributed surface loads. These functions will allow for modeling of GIA for realistic ice load scenarios imposed above potentially complex earth structures.

Presenting author	Christine Kollsgård University of Tromsø
Title	Dynamics of the northern Barents Sea Ice Sheet during the last glacial – interglacial cycle
Key words	Kvitøya, Glacial, Interglacial, Sedimentology, Lithostratigraphy, Ice Sheet, Dynamics, Timing, Slope
Abstract	Kollsgård, C.T.1,*, Laberg, J.S.1, Rydningen, T.A.1, Husum, K.2, Lasabuda, A.1,3 & Forwick, M.1. 1Department of Geosciences, UiT The Arctic University of Norway, 9037 Tromsø, Norway 2Norwegian Polar Institute, Tromsø, Norway 3Research Centre for Arctic Petroleum Exploration (ARCEx) *e-mail: christine.t.kollsgard@uit.no The precise timing and dynamics of the northern part of the Barents Sea Ice Sheet, its triggering mechanisms, as well as older glacial fluctuations remain poorly constrained. This study aims to investigate the continental slope of the northeastern Svalbard-Barents Sea margin, in particular offshore of the Kvitøya Trough, to better understand the dynamics of the ice sheet. The sediment deposits elucidate the interplay between downslope processes resulting from input of subglacial sediments, glacimarine processes of ice sheet meltwater and ice rafting, and alongslope processes from ocean currents. A total of four gravity and Calypso cores (4.61 to 18 m long) were retrieved from the inter-fan areas at the continental slope offshore of the Kvitøya Trough in water depths from ca. 500-3300 m. In addition, swath bathymetry and high-resolution sub-bottom profiles were acquired by the Helmer Hanssen and Kronprins Haakon research vessels as parts of the Arctic Marine Geology and Geophysics Research School cruise of UiT The Arctic University of Norway and the Nansen Legacy paleo cruise, respectively. Results from multi-proxy analyses of the sediment cores will be presented including lithostratigraphy, physical properties, grain-size distribution, XRF core scanning and radiocarbon dates.

Presenting author	Laura Dietrich University of Bergen/GFI
Title	Performance of the regional climate model MAR in the accumulation zone of Greenland
Key words	MAR, regional climate model, Greenland Ice sheet, accumulation zone
Abstract	When snow forms it stores an isotopic fingerprint of the water vapor in the atmosphere. Ice cores contain a time series of these fingerprints and can be used to estimate a time evolution of atmospheric state of the past. The previously underlying assumption was that the isotopic composition of the snow does not change after the deposition. However, several recent studies have found evidence that the isotopic composition of the snow surface is highly impacted by post-depositional processes. My work is part of the SNOWISO project which has the goal to develop a new understanding of the isotopic signal in ice core records to get accurate information of the past climate that take these post-depositional influences into account. For this purpose, I will implement parameterisations of these post-depositional influences into the isotope-enabled regional climate model MAR (Modèle Atmophérique Régional) in order to simulate the water stable isotopes' fluxes at the snow surface. The simulations will be used to quantify the fraction of the post-depositional changes in the isotopic signal in ice cores. In my poster I present the performance of MAR in the dry, desert like conditions at the interior of the ice sheet using four years of observations carried out as part of EastGrip (The East Greenland Ice-core Project). This dataset gives a unique possibility to evaluate the performance of MAR in the accumulation zone of Greenland. In particular, I will address BIASes and uncertainties in the simulation of the surface fluxes.