

Oslo, 30 December 2024

LATICE – Annual letter 2024

Dear all,

2024 is coming to an end and it is time to reflect on the activities and progress made in the year that passed - our tenth and last year of LATICE in terms of funding by the faculty. With this in mind we should reflect – not only on the last year – but on the past 10 years and where we want to go from here. Thus, a key focus this year has been on strategy discussions on the future of LATICE (more details are given in the last paragraph). Before elaborating our thoughts on the past and future, we would like to thank you all for your contribution to making 2024 another interesting and motivating LATICE year. The high level of activity and the many achievements are due not only to LATICE, but to the many projects and people that are closely associated with it.

Significant time has been devoted to three main LATICE activities, all with important contributions from associated projects; i) the continuing collection and analysis of data from LATICE Flux and associated sites, encompassing various infrastructure and field investigations, ii) further developing of key facilities of the Cold Climate Container, notable the production of snow, and iii) the LATICE Model Intercomparison Project's two main activities (LATICE-MIP Snow and Evaporation). The two first activities contribute new observations that are vital for improved process understanding and support novel parametrisation of high latitude processes in land surface and hydrological models (as exemplified by the third activity).

The LATICE 2024 annual meeting was held on 5 December in the Climate House at Tøyen, Oslo, in the form of a half-day Christmas seminar, closing with lunch. The Climate House is a special venue for LATICE scientists since they contributed to the opening of the house with a temporary climate exhibition in 2019. The main aim of the meeting was to get an update of LATICE relevant activities providing ample time for discussions, with emphasis on future work and collaboration. In total ten presentations were given and 20 members took part. Prior to the seminar, a breakfast seminar was held by Anders Bryn entitled “Er Naturavtalen i veien for Parisavtalen?”, which gathered significant interest and discussion among the participants.

The LATICE funded PhD candidate Lasse Torben Keetz defended his thesis "Unraveling the emerald planet: learning vegetation-environment interactions from data" for the degree of Philosophiae Doctor, 11 October at the Department of Geosciences. Earlier the same day he gave a trial lecture entitled “The past and future roles of machine learning in land surface modelling”. Lasse is now a Researcher at the department contributing to the ACTIVATE project led by Norbert Pirk.

Two PhD candidates associated with LATICE also completed their degrees of Philosophiae Doctors in 2024, both at the Department of Geosciences (UiO). Eirik Aasmo Finne gave his trial lecture “Vegetation-climate interaction at the global scale” on 12 June, followed by the defense of his thesis “On the role of lichens in vegetation-climate interactions” on the same day. A few days later, on 18 June, Elin Cecilie Ristorp Aas defended her thesis “To mimic microbes with models: Development and application of the

microbially explicit soil model MIMICS+ in cold climates”. She gave her trial lecture “Ecosystem services of high-latitude soils in a changing climate” earlier the same day. Elin is now a Researcher with MetNo, and Eirik is a Postdoctoral Fellow at the Arctic University of Norway (UiT) in Tromsø. All theses are freely available for download on duo.uio.no.

Some further highlights and details of activities in 2024 are presented below.

Infrastructure and Observations

Our flux measurement sites operated well during the last year. At Finse, most sensors reported useful measurements throughout 2024, but we have had a few issues with logging the eddy covariance data during the autumn, which are still to be resolved. The flux station at Işkoras worked nicely to provide continuous baseline estimates for carbon and energy exchange, as well as for meteorological and soil conditions. The BioGov project, associated with the Centre for Biogeochemistry in the Anthropocene (CBA), among others, keeps on using Işkoras as a key research site for which the flux tower delivers invaluable data. At the Hedmark (Hisåsen) twin sites, where one of the drained mires was restored during the autumn of 2021, we have been able to document the carbon, energy and water balance in the third year after restoration. Preliminary analyses show that the increased methane emissions due to the re-wetting persisted in 2024, while CO₂ fluxes almost returned to their pre-restoration levels this year. A manuscript describing the carbon balance of the restoration experiment is in preparation, led by Postdoc Michael Bekken (Fulbright Grantee, now at NIBIO) in collaboration with our Danish partners. We maintained our collaboration with NIBIO (PI Holger Lange), NMBU (PI Mareile A. Wolff) and MetNo (PI Laura Ehrnsperger), responsible for the ICOS-Norway site at Hurdal (NIBIO) and a grassland flux site at Ås (NMBU and MetNo), respectively.

MobileFlux-2, our hyper-mobile CO₂/H₂O flux system, has been moved around at numerous sites in 2024, such as on Svalbard, Gaustatoppen, Langtjern, Bulidalen, Blindern, and back to Gaustatoppen. Its data is primarily used by PhD students Malin Ahlbäck (SnowSub project) and Gunnar Liahjell (TRES-Hydro project), as well as in MSc student projects.

The LATICE cold climate container is steadily being developed into a key laboratory for our projects. A snowmaker is now up and running in the lab, providing the backbone for experiments of the SnowSub project led by Olga Silantyeva. The work is done in collaboration with Researcher Shaakir Dar at the Oulu University, Finland, with valuable support from our technician John Hulth. Shaakir spent two months in the autumn of 2024 preparing the container for experiments, involving sensor installation and automating isotopic measurements during snow production. There were several obstacles on the way, and some repairs and modifications are needed for the experiments to be run early next year. We are excited to see the upcoming results from these experiments as well as others providing new insights on the critical snow-atmosphere interface.

The drone-based flux mapping technique developed within the Research Council of Norway (RCN) Spot-On project is further being developed and tested. The approach combines meteorological measurements on drones with turbulence-resolving large eddy simulations using data assimilation to infer surface fluxes. Our dScience PhD student Alouette van Hove is further refining the technique by adding functionality to find optimal sampling strategies for the drones. Her paper entitled “Guiding drones by information gain” was presented at the Northern Lights Deep Learning Conference in Tromsø in January 2024. Her latest work on

“Inferring methane emissions from African livestock by fusing drone, tower, and satellite data” will be in discussion in the Biogeosciences journal during the next months.

Land surface and Hydrological model developments

After many years of experience and built know-how, one of our CLM/FATES group members, namely Lasse Keetz, completed the implementation of a data assimilation framework (with help of Kristoffer Aalstad) in the CLM/FATES model by also including machine learning methods. This has been a big technical challenge, not only for our research group, but also in the larger land-surface modeling communities. Therefore, it is an important contribution for the relevant science communities. The theory and code work behind this new implementation have been submitted as a research paper (JAMES) and became a part of the successfully defended PhD thesis by Lasse. We are lucky that he continues as a researcher at the Department of Geosciences, where he will be able to build on this work in his research, now within the ACTIVATE project.

ACTIVATE - 'Actively learning experimental design in terrestrial climate science' is an ERC funded Starting grant awarded to Norbert Pirk. It runs for five years (2024-2028). The project combines an observing system consisting of a swarm of drones carrying meteorological sensors and gas analysers, mobile and stationary flux towers, as well as satellites, and fuses their observations with different land-atmosphere models using data assimilation methods. The ACTIVATE team used 2024 to improve drone infrastructure and flux inference methods. A field campaign – featuring drone flights with a sonic anemometer, a gas analyser for point measurements of methane, and retro-reflectors for path-average methane concentrations – was conducted at a lagoon pingo site on Svalbard. The team is also exploring different likelihood emulators to speed up the flux inference to enable active learning capabilities.

Iris Mužić (PhD at CICERO, previously LATICE intern) approaches the end of her PhD research by using the coupled climate model WRF-CTSM as the main tool for analysing land-atmosphere interactions over the Nordic region. She has been able to run this model with its recently developed hillslope hydrology feature, which allows to explore the role of topography and hydrology on the soil moisture and snowpack variability. She has submitted one manuscript, and another is currently in preparation. Terje Berntsen and Yeliz Yilmaz are co-supervisors, strengthening the links between CICERO and LATICE partners. She is also closely working and sharing her modeling experience with Gunnar Liahjell for his PhD work in the TREX-Hydro project.

LATICE-MIP Snow group (led by Yeliz Yilmaz, UiO) hosted in spring a visiting ERASMUS master student, Arnaud Jansen from the Wageningen University in the Netherlands, at the Department of Geosciences. He conducted his master's thesis on “Response of snowmelt rate and streamflow to climate change: case study in Hardangervidda, Norway” with help from Yeliz and Kristoffer Aalstad. In his work he was able to combine previously produced LATICE tools and data, which served as a proof-of-concept and led to new results about changing snow dynamics in one of the biggest high mountain plateaus in Europe. The methodology developed can be applied in other cold environments. A manuscript based on his master thesis is currently in preparation. It is important to highlight in this context, the strength of the LATICE initiative and community in facilitating this rather technically challenging task - especially for a master thesis study that needs to be completed within a limited period of time. This was made possible with the joint support from several people and building on recent developments, including guidance in using the

MuSA snow data assimilation toolbox from Esteban Alonso-González and Marco Mazzolini, access to high-resolution input data created by Yeliz Yilmaz from MODIS data as well as TopoSCALE forcing data and data assimilation help from Kristoffer Aalstad.

PATCHES (Probabilistic reAnalysis of the Terrestrial Cryosphere by History-matching using Evidence from Satellites) led by Kristoffer Aalstad is funded by a Climate Change Initiative (CCI) Research Fellowship from the European Space Agency. After the first year, he was able to create the very first prototype of daily estimates of snow water equivalent for 1 km pixels covering the entire Earth's seasonally snow-covered areas. This will be the first of a kind product for his ESA project.

SnowBridges: bridging models, observations and people, is a new initiative by UiO researchers that aims to bridge ongoing snow related research activities in Norway. It addresses data availability and sharing, snow as an academic topic, challenges for snow sciences in Norway, and future perspectives. The group organised a full-day workshop (17 September), launching the initiative, with the support from several contributing projects at UiO (SNOWDEPTH, SnowSub, PATCHES, ACTIVATE and LATICE). The workshop gained a lot of interest and engagement with 42 participants from 15 organisations across Norway. The program consisted of short science updates from participants focusing on ongoing activities and potential collaborations. There was broad agreement to establish a network among the workshop participants. A smaller committee with representatives from various institutions is already planning next year's SnowBridges workshop.

The LATICE-MIP Evaporation group (led by Kolbjørn Engeland, NVE) focuses on evaporation as a component of the water cycle and is motivated by the large uncertainties in simulated annual water balance in Norway. It involves researchers from several organisations in the Oslo region (MetNo, NIBIO, NVE and UiO) with expertise on different types of models. Three hydrologic models (HBV, Shyft and LISFLOOD) and two land surface models (CLM and SURFEX) are compared at three spatial scales: the point scale (site level) encompassing several flux sites (Finse, Hedmark, Hurdal, Iškora and Ås), the catchment scale including more than 100 near-natural catchments in Norway, and the regional scale covering all of mainland Norway. During 2024, catchment-scale model calibrations were performed using HBV, Shyft and LISFLOOD, and by testing several objective functions in order to assess the sensitivity of simulated discharge and evaporation.

The hydrologic and water resources model LISFLOOD, which is developed by the European Commission's Joint Research Centre (JRC) and the European Centre for Medium-Range Weather Forecasts (ECMWF), has been used for both educational and research purposes at UiO. MSc student Frøya E. N. Konst applied it, in her thesis, to ten unregulated catchments in Norway in order to assess the effect of lakes on the simulation of river discharge. This work is now being continued and extended to all of Norway by LATICE postdoc Emiliano Gelati. In collaboration with NVE and the EU-funded STARS4Water research project, LISFLOOD has also been applied to the heavily regulated Drammen catchment.

New associated projects, initiatives and proposals

Several new projects of relevance to LATICE have obtained funding from the Research Council (RCN) and will start in 2025. A majority of these are led by associated LATICE members (i.e., not from UiO), including CICERO, MetNo, NORCE and NIBIO, with partners from UiO. Frans-Jan Parmentier's (UiO) proposal SNOWLESS was among those funded (will among other use the Cold Climate Container for

experiments), and his NORDFORSK proposal CASCADES has passed on to the second round (contributions from other LATICE partners).

Following the LATICE strategy meeting at Lysebu, it was decided to submit a proposal to the UiO:Energy Convergence call with deadline in November. Anders Bryn, Yeliz Yilmaz and Eva Lieungh prepared and submitted a pre-proposal with the title: “Direct and indirect Effects of Renewable Energy Infrastructure on land use, climate, and ecosystems (E-REIN)”. The main aims of E-REIN is to, within a multi-disciplinary framework, assess the direct and indirect effects of renewable energy infrastructure on land use, climate, and ecosystems. The project plans to use the relocation of reindeer from Fosen to Os or Tolga as a case study with respect to wind power, and most likely construction in Stor-Elvdal or Alvdal as a case study with respect to solar power. We learned just before Christmas that the project has gone to the second stage with a deadline to submit the full proposal by the end of February.

New team members

The LATICE-funded group consisted in 2024 of two PhDs (Lasse Keetz and Astrid Vatne) and one Postdoc (Emiliano Gelati) funded by the faculty. Lasse Keetz defended his thesis in October, whereas Astrid Vatne was back from her maternity leave in September 2024, returning to her position at NVE, but with time allocated to complete her thesis work (planned for 2025). In addition, several other researchers, Postdocs and PhDs associated with LATICE contributed through collaborative projects, many of them with important fieldwork at Finse and other high latitude sites in Norway.

Lasse Keetz joined the team of researchers in the ACTIVATE project to continue his work on LSM data assimilation frameworks, active learning, and drone data fusion.

Johan Agerup joined the ACTIVATE team as a new PhD student, focusing on hardware developments, active learning capabilities, and field applications. His background in machine learning and computational sciences will be a great addition to the team.

Akhilesh Nair was hired as a researcher in the EU-funded Water4All project GroundedExtremes, which investigates groundwater and hydrological extremes. He previously worked at UiB where he contributed to the development of the Norwegian Climate Prediction Model (combining NorESM and data assimilation). His experience with land surface modelling and land-atmosphere feedbacks, in particular, is a valuable asset to LATICE.

Ingrid Vesterdal Tjessem started as a PhD in the Natural History Museum (in 2023). The overall aim of her research is mapping of Arctic, alpine and boreal vegetation in Finnmark, including forest and tree lines Her work will mainly be based on field work.

We are pleased to have you all as part of the LATICE team.

Interdisciplinary teaching and training

GEO9915/5915 - Ecological Climatology, led by Anders Bryn and Frode Stordal, was taught for the sixth time in spring 2024. It is given every second year and the next course is planned for 2026. GEO3032 - Climate Change and Impacts - was given for the fourth time in spring 2024, whereas GEO4990/9990 – The

Earth System - was given for the second time in fall 2024 (both courses are coordinated by MetOs). LATICE members contribute with several lectures to these three interdisciplinary courses.

Dissemination and Communication

The group has been active in dissemination and communicating the LATICE project and our research at various national and international conferences and events, such as the EGU24 conference in Vienna in April. The LATICE member, Yeliz Yilmaz, gave a talk at the 9th Global Energy and Water exchange (GEWEX) Open Science conference (7-12 July, Sapporo, Japan), presenting key achievements of the LATICE and EMERALD projects. A total of 127 scientists from 33 countries from all continents participated in the event. Contributions from LATICE scientists at these and other events are provided at our LATICE website (see 'News').

Three LATICE seminars were arranged in 2024 (also attendance on Zoom), providing a discussion forum for new research initiatives, funding applications, interaction with related projects, and regular updates on field and modelling activities. A complete list can be found on the [“events” page](#) of the LATICE website.

The exhibition "Natur i endring" (A changing nature) remained at the Norwegian Mountain Centre in Lom also throughout 2024, acknowledging among others the LATICE project. Visitors learn how climate scientists measure the amount of snow and the soil temperature in alpine areas, and how studies of plant communities are executed. It is based on an exhibition originally made for the Climate House at the Natural History Museum (NHM), but largely expanded and with new activities especially aimed at a younger audience.

We have a CRiStin project page for LATICE where all are encouraged to link their LATICE relevant publications: <https://app.cristin.no/projects/show.jsf?id=2492739>. Check out our website for recently published highlighted articles.

LATICE strategy meeting, 24-25 October, Lysebu, Oslo.

The LATICE coordination team (Lena, Yeliz, Norbert, Frode) has on several occasions discussed the future of LATICE given that 2024 is officially the last year of LATICE. As part of this process, we organised a 2-day strategy meeting in October at Lysebu. Elements of the EMERALD project were also integrated in the discussion, in particular the option to revitalise the biannual national event “Network seminar on terrestrial vegetation ecological climatology”, which the LATICE group arranged prior to EMERALD. In addition to the coordination team, we invited Terje Berntsen, Anders Bryn, Olav Skarpaas (not available) and Jarle Bjerke to join. LATICE has i) enabled us to become a knowledge hub within land-atmosphere interactions and land surface modelling at high latitudes, ii) made us an attractive partner in research proposals nationally - partly due to the extensive investment in novel infrastructure, and iii) led to a high number of proposals and external funding. With this background, the purpose of the meeting was to i) discuss where we (LATICE) stand, where we want to go and how to get there, ii) decide on a new organisation and management structure, and iii) decide on the next steps including getting feedback from a broader group (strategic discussions). Considerable time was also spent on new opportunities and potential proposals (ref. The UiO:Energy proposal), how to maintain the high level of national collaboration and enhance international collaboration, as well as planning of activities ahead. We did not conclude on all aspects and will continue our strategic discussions in the time ahead.

Thanks to you all, we have been able to maintain a high level of activities in the field, lab as well as within the modelling groups. We look forward to continuing our joint effort in the year to come with exciting research results emerging from existing and new projects and activities. In particular, we will continue our strategic discussion on the future of LATICE with our collaborative members, now that we are entering a new phase of LATICE. The creative, friendly and open atmosphere that characterises our collaboration makes it a motivating and great project to endorse. Thus, we have concluded that it is worth engaging in LATICE further and hope to have many of you with us on the way ahead.

With our best wishes for the New Year - Godt Nyttår!

Lena, Frode, Norbert, Yeliz, and Emiliano

LATICE coordination team