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Consortia funded in Key Areas of Green and Digital Transition call 2021

Urban Environment and Climate Change in The Arctic: Data-Driven Intelligence Approach to Multihazard Mitigation

Elena Kozlovskaya, University of Oulu

Jaakko Suutala, University of Oulu; Jarkko Okkonen, Geological Survey of Finland

Despite measures taken to reduce emission of greenhouse gases to the atmosphere, the processes initiated by climate change and their negative consequences cannot be stopped immediately. In the Arctic and sub-Arctic areas, roads are particularly vulnerable and exposed to changes in winter weather conditions caused by climate change. For example, thin snow cover and rapid temperature decrease may cause massive fracturing in the shallow subsurface (frost quakes) and hence mechanical damage to the pavements and roads. The key tool to decrease economic losses due to this damage is to react before the strength and stability of roads and pavements weakens. In our project we shall develop a methodology for monitoring and prediction of seasonal changes of road conditions that uses physics-guided machine learning and artificial intelligence. The results can be used as a tool for proactive maintenance that would give longer lifetimes, savings and better roads and pavements in the long run.

Unmanned aerial systems-based solutions for real-time management of wildfire

Eija Honkavaara, Finnish Geospatial Research Institute; Tuomo Hänninen, University of Oulu; Ilkka Pölönen, University of Jyväskylä; Fabrice Saffre, VTT Oy

Wildfires are one of the major global environmental threats posed by climate change. The objective of the FireMan consortium is to develop novel, disruptive AI-based technology for a fast detection of wildfires and for creating situational awareness during the wildfire event using unmanned aerial systems (UASs, drones). The research will consider aspects of autonomous flying using beyond visual line of sight drones and drone swarms, connectivity, and autonomous extraction of situational awareness using remote sensing and develop a DigitalTwin based decision support system for wildfire management. The multidisciplinary consortium is formed by researchers from the Finnish Geospatial Research Institute, Universities of Jyväskylä and Oulu and VTT and an extensive collaboration network. FireMan will create scientific breakthroughs and societal impacts by developing digital and low-emission technologies that will greatly support the objectives of adapting and mitigating climate change.

Artificial Intelligence for Urban Low-Emission Autonomous Traffic (AIforLEssAuto)

Laura Ruotsalainen, University of Helsinki
Leena Järvi, Ville Kyrki: University of Helsinki; Claudio Roncoli, Aalto University

At present, road transport contributes a significant amount to the total carbon dioxide (CO2) emissions in the EU. AIforLEssAuto brings together atmospheric and computer scientists, and traffic engineers in active dialogue with municipal stakeholders with the ultimate aim to understand how autonomous electrified traffic should be organized during the transition period in order to reduce carbon emissions. This is achieved by building a framework of computational

modelling tools to evaluate the CO2 emissions originating from electrified automated vehicles, and by developing artificial intelligence based control from vehicle-level to city-center wide traffic-level in which CO2 emissions are minimized. Such multidisciplinary approach has not been done to this extent before and thus AIforLEssAuto advances the state of scientific research in all disciplines involved and the novel combination will certainly lead to new, scientifically and societally, important breakthroughs.

WindySea - Modelling engine to design, assess environmental impacts, and operate wind farms for ice-covered waters

Arttu Polojärvi, Aalto University
Jari Haapala, Finnish Meteorological Institute; Jaakko Heinonen, VTT OY

The European Union aims to increase energy production by offshore wind farms (OWFs) from present 12 GW to 300 GW by year 2050. Many northern sea areas, such as the Bothnian Sea and the Gulf of Bothnia, have been identified as suitable for offshore wind farms. Key challenge related to the OWF developments in all northern sea areas is the interaction OWFs and moving sea ice: It is difficult to design cost-effective yet safe wind turbine units due to high sea ice loads. This halts OWF construction in ice covered seas. WindySea proposes to build a framework for a “Digital Twin of a cold regions OWF”, a multi-physics modeling engine for forecasting future marine environmental and ice conditions, while simultaneously being detailed enough for the design and optimization of cold regions OWFs. Aim is to accelerate green transition by optimizing OWFs and wind turbine structures through research on the effects cold marine environment to OWFs and OWFs impact to cold marine environment.

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Microscopy and machine learning in molecular characterization of lignocellulosic materials (MIMIC)

Adam Foster, Aalto University
Peter Liljeroth, Aalto University; Joni Lehto, VTT OY

Lignocellulosic materials, the essential components of plant matter, are organized in complex three-dimensional structures, where detailed understanding of the interactions between the different polymer components is still an unresolved challenge. In this proposal, a novel microscopy imaging and artificial intelligence infrastructure is used to visualize individual lignocellulosic building blocks and their assembled structures at an unprecedented resolution. The application potential is in gaining information to improve biorefinery processes - serving in the development of selective dissolution processes for producing purified streams of cellulose, lignin and hemicelluloses. It can also be applied in new technologies for producing natural textile fibers and to reveal the detailed surface structure of lignocellulosic materials, essential for enzyme-aided or chemical modification in biorefineries.

Materials Development for Flow Batteries with Help of Explainable AI

Pekka Peljo, University of Turku
Kari Laasonen, Aalto University; Petri Pihko, University of Jyväskylä

The electrical energy storage is the key problem to be solved to realize green transition in electricity generation. Redox flow batteries (RFBs) offer promise for large scale energy storage, but current technology requires critical materials like vanadium and therefore remain too expensive. Instead, affordable RFBs based on renewable or abundant raw materials are needed. The potential molecules need to fulfil several criteria, including a reasonable high energy density, stability, and production at an affordable cost, but no such molecules have been discovered yet. FlowXAI will develop procedures to screen a vast number of molecules, utilizing

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both computational chemistry and machine learning, complemented with targeted molecular synthesis and automated synthesis and testing of flow battery chemical.

Managing Forests for Climate Change Mitigation (ForClimate)

Markku Kulmala, University of Helsinki
Anna Lintunen, University of Helsinki; Jari Hynynen, National Resources Institute of Finland; Annalea Lohila, Finnish Meteorological Institute

The aim of the project is to resolve efficient forest management strategies to strengthen the ability of forests to mitigate climate change. We analyze the impacts of forest management and changing climate on forest carbon sink and radiative forcing by combining comprehensive long-term data sets on boreal forests and the atmosphere with diverse forest growth modelling. We develop a synthesis model MottiC+ and a stand simulation tool available online for public use. The model will allow assessing forest–atmosphere interactions in different management and climate scenarios at various scales accounting not only for carbon sink, but also other forest climate impacts (other GHG's, albedo and aerosols). We will also produce an open online MOOC course on forest use and climate impacts. The interdisciplinary consortium includes scientists from the University of Helsinki, the Natural Resources Institute Finland and the Finnish Meteorological Institute as well as forest sector collaborators.

Green and digital transition in river basin management (Green-Digi-Basin)

Petteri Alho, University of Turku
Harri Kaartinen, Finnish Geospatial Research Institute, Eliisa Lotsari, Aalto University; Hannu Marttila, University of Helsinki; Anna-Kaisa Ronkanen, Finnish Environment Institute

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In Green-Digi-Basin, we will use multidisciplinary approaches, novel technologies and smart solution in close collaboration with different stakeholders and end-users to provide crucial information for sustainable and resilient water resources management. The project is strongly connected to the existing competence center a.k.a. HYDRO-RDI-Network. We are aiming to find the most effective green solutions for the boreal-subarctic river basins and improve current calculations for river connectivity, nutrient and carbon loads to surface water systems from different land use. We further consider land use scenarios including various types of green solutions (e.g. peatland restoration, wetland, gypsum treatment) for predicting water volume and quality in the river basin scale.

Foundations for green offshore energy production in Finland: from marine investigations to the numerical estimation of undrained shear strength of the seabed deposit layers under cycling loading

Wojciech Solowski, Aalto University
Joonas Virtasalo, Geological Survey of Finland

The project will investigate seabed structures in the Finnish Baltic Sea. The investigations will consist of remote sensing methods and on-site tests. As the on-site tests do not give accurate enough results about the seabed structures, the project will develop new methods of interpretation of this digital data. The project will also collect and test samples from the seabed, investigating and modelling their behaviour both in the initial condition and after cycles of loads, corresponding to those induced by wind and waves. The project will also help to assess the risk of underwater landslides in a given area. The project will advance the digital methods and allow for the economical design of green energy offshore structures, such as wind turbines. The project will also help in designing infrastructure such as pipes or cables linking the structures with land, as such infrastructure is sensitive to underwater landslides.

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Evaluating integrated spatially explicit carbon-neutrality for boreal landscapes and regions

Martin Forsius, Finnish Environment Institute
Mika Aurela, Finnish Meteorological Institute; Timo Kumpula, University of Eastern Finland; Annikki Mäkelä, University of Helsinki

The challenges posed by climate change, biodiversity loss and harmful land-use are deeply interconnected. The overall objective of the project is to provide top-class spatially explicit information on the potential for reaching carbon-neutrality in boreal landscapes and regions, considering sustainability issues. Advanced modelling and remote sensing techniques are developed and utilized. Both anthropogenic and land-use based greenhouse gas (GHG) emissions are evaluated. Data from top-class research sites is used. The policy-relevant aim is to provide detailed spatial, scenario-based information at different scales for key end-users (e.g. communities, provinces, ministries). This information can be used for e.g. regional land-use and energy strategy planning/management, and sustainability assessment. The project is carried out by a multidisciplinary team from the Finnish Environment Institute, Finnish Meteorological Institute and the universities of Helsinki and Eastern Finland.

Enzyme-mediated attachment and detachment of multifunctional and biobased coating aided by digital material design (ENZYFUNC)

Monika Österberg, Aalto University
Anu Koivula, VTT Oy; Pekka Saranpää, National Resources Institute of Finland

Nontechnical description in English ENZYFUNC project will focus on developing sustainable and scalable surface functionalization methods for cellulosic surfaces by enzymatic means. The aim is to gain superhydrophobicity, UV-resistance and antimicrobial activity on surfaces. Enzymes will be used for covalent attachment of fatty acid molecules and natural wax and lignin particles

onto surfaces to improve the durability of coatings. The coatings can later on be removed selectively by enzymes, which in turn improves the recyclability of the materials. Our approach will combine enzymatic methods with computational modelling and environmental impact estimation that will result in biobased hydrophobic coatings that are durable, but easy to remove, and a coating technology that will increase the use of cellulose in textiles and packaging.

EasyDR - Enabling demand response through easy to use open source approach

Anders Lindfors, Finnish Meteorological Institute
Juha Kiviluoma, VTT Oy; Fabricio Oliveira, Aalto University; Enni Ruokamo, Finnish Environment Institute

De-carbonizing energy system is the main avenue to mitigate climate change. This project attempts to enable large scale flexibility of electricity consumption at the residential scale, which in turn will allow more variable power generation, such as wind power and photovoltaics, to be cost effectively integrated in the energy system. The project will use existing low cost components combined with open source software, since cost has so far been a major barrier for successful residential demand response. We are also taking behavioral barriers very seriously and designing the system from the user perspective advised by lessons from research. However, under the hood, the control system will use state-of-the-art stochastic energy weather forecasts, energy system optimization and control systems. While the system is tested in the Finnish context, it will be generic and allows customization for other regions and purposes.

Digitally mediated decarbon communities in energy transition

Sampsa Hyysalo, Aalto University
Jouni Juntunen, University of Vaasa; Kaisa Kurki, Finnish Environment Institute

The “demand side” of the market, actions by citizens as consumers and producers of to low carbon energy now plays an increasing role in the decarbonization of energy and built environment that are the largest carbon polluters in EU. The synergies between energy and digital technologies open new opportunities for novel forms of citizen and community action. We investigate the new digitally mediated energy communities in Finland: the forms and dynamics of digitally enabled citizen energy communities; the presently emerging collaborative business ecosystems related to them; the recent policy reforms and policy coherence related to energy communities as well as the role of public sector; and potential of wide digitalized participation arenas for elaborating the future pathways of energy communities. DigiDecarbon is part of a networked competence cluster that is comprised of academic, policy, industry and practitioner actors who focus on the demand side of the energy transition.

Capturing structural and functional diversity of trees and tree communities for supporting sustainable use of forests

Mikko Vastaranta, University of Eastern Finland
Juha Hyyppä, Finnish Geospatial Research Institute

To capture uniqueness of trees and to demonstrate how it could be used to improve wood tracking we will develop laser scanning-based methodologies and solutions that will be also beneficial for biodiversity mapping and monitoring. Based on the past development, we presume that what can be done for tree communities today with laser scanning, can be done at the national level within 10-15 years. Our investigations of structural and functional characteristics of trees and tree communities will lead to applications, technology transfer and dissemination actions including international tests in Belgium, Canada, China and Japan, demonstrations of wood tracking, and development of tools for monitoring forest biodiversity. Our research actions are built on new Measuring Spatiotemporal Changes in Forest Ecosystem

(Scan4est) research infrastructure and are in the core of the Forest-Human-Machine Interplay Flagship of Science (UNITE).

Sustainable and autonomous carbon-neutral aerial ecosystems and energy solutions for future metropolises (AeroPolis)

Juha Röning, University of Oulu
Tomi Westerlund, University of Turku; Harry Edelman, University of Tampere; Jani Oksanen, Aalto University

Solving the challenges of future transportation requires a solid understanding of the megatrends in urbanization, digitalization and energy. Automated vehicles in particular create new zero-carbon services when combined with renewable energy and urban design and attractive opportunities are found in the development of autonomous aerial vehicles, addressing greener last-mile delivery services. Several challenges in this sector are also shared throughout other fields, ideally making the related automation and energy solutions universal. AeroPolis proposes a new take on the aerial logistics ecosystem by defining how autonomous urban-embedded micro-airports and open logistics-ready drones can redefine and advance the current technological possibilities. This is then combined with a digital platform that leverages distributed ledger technologies (DLTs), advanced aerial autonomy and ground-to-air coordination approaches, and integrated hybrid renewable solar+fuel cell energy solutions.

Artificial Intelligence for Twinning the Diversity, Productivity and Spectral Signature of Forests

Matti Mõttus, VTT Oy
Miina Rautiainen, Jorma Laaksonen: Aalto University; Mari Myllymäki, National Resources Institute of Finland

The overall objective of ARTISDIG is to pioneer the science behind a digital twin of the Earth's forests, capturing their diversity, growth and productivity. New scientific results would enable to integrate forest biodiversity in the Digital Twin Earth, which is being implemented via the Destination Earth (DestinE) initiative as a part of the European Green Deal. ARTISDIG will develop novel methods to quantify and monitor boreal forests' structural and spectral variation by applying AI-based algorithms to interpret satellite data. The ground-breaking idea is to combine physical and AI models, which has been identified as a significant scientific challenge in the forthcoming years. Our interdisciplinary consortium brings together experts of digital twins and remote sensing (VTT), forest sciences and statistical analyses (Natural Resource Institute Finland), and artificial intelligence and vegetation spectroscopy (Aalto university).

AI-guided CO2 Conversion

Annukka Santasalo-Aarnio, Aalto University
Patrick Rinke, Aalto University

To mitigate climate change, we need to fully replace fossil sources as raw materials for future fuels and carbon-based products, such as plastics. As these products are still needed, we must find more sustainable carbon sources. CO2 captured from industrial sources and directly from air provides carbon and reduces greenhouse gas emissions. However, to use the carbon in CO2, it needs to be transformed into fuels and products through hydrogenation, a process that is currently inefficient, and improvements to it are slow. In AIcon we will accelerate the development of better CO2 hydrogenation technology with artificial intelligence (AI). We combine AI-guided exploration and optimization with catalysts synthesis and lab reactors to find better catalysts and optimal processing conditions for CO2 hydrogenation. Our digitized workflow enables us to speed up the technological development process and the CO2 use-case will serve as a template for knowledge transfer to other green technologies.