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CTK

ADAPTINFA: Extreme winter weather events and their impact on roads condition: combining physics and AI

University of Oulu: Oulu Mining School and Biomimetic and Intelligent Systems Group Geological Survey of Finland: Water Management Unit

11.12.2024

MAIN PROBLEM: ADAPTATION TO CLIMATE CHANGE

#### • WHY ADAPTATION?

• In spite of measures taken, the climate change cannot be stopped immediately

EXTREME WINTER WEATHER CONDITIONS

- WHY EXTREME WEATHER?
- The frequency and severity of extreme weather will most probably increase in the future

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SUSTAINABLE FUNCTIONING OF ROADS

- WHY ROADS?
- The well-being of communities in the Arctic depend on them

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#### 1.OBSERVATIONS: extreme weather episodes (fast freezing) in winter 2022-2023 in Oulu, road fracturing and other damages





On 6.01.2023, 4.02.2023, 6.03.2023 the local inhabitants in Talvikangas reported unusually loud noise in the early morning. On the same days, they detected new cracks on roads, walls and foundations of buildings and tree trunks.



A tree trunk damage appeared on 6.03.2023 in Talvikangas



11.12.2024

#### WHERE THE FROSTQUAKES OCCUR?

484 985E



On 6.01.2023 we detected and located:

- 11 frostquakes in Talvikangas
- 34 frostquakes in Tähtelä



- Frostquakes Oulu sources in (Talvikangas) are mainly located on irrigated wetlands
- Frostquakes detected in Sodankylä (Tähtelä) were caused by
- a) ice fracturing on the Kitinen river;
- b) fractures on small roads in Sodankylä geophysical observatory (Tähtelä).
- c) fractures in wetland and irrigation channels. 11.12.2024

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#### How large ground shaking produces frostquake?



The ground shaking, produced by a typical frostquake in a wetland near Talvikangas in Oulu on 6.01.2023, was equal to those produced by a mining blast at the same distance or by a heavy cargo train moving at a distance of 10 m.

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#### 2. Frozen soils mechanics:

- Cryosuction pressure increases due to fast freezing when the air temperature rapidly drops
- Massive fracturing in frozen soil (frost quakes) occur at the same time





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# **3.** Modelling of frozen soil conditions for Finland using HydroBlock model: EXAMPLE: Snow water equivalent on 6.01.2016 (SWE)







### Results from HydroBlocks: Soil temperature during rapid freezing





## 3. Efficient AI emulators for physics-based simulators: soil temperature modelling





Comp.	Method		
times	GPR	MLP	Simulator
Training	14.0	79.0	-
Inference	0.2	1.8	-
Total	14.2	80.8	320.0

Table: Soil temperature computation times.



### Snow water equivalent forecasting with recurrent neural networks







#### 4. Road quality forecasting with machine learning









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#### **Collaborators:**

**TU Freiberg**, Germany **Oak Ridge National Laboratory, USA Duke University, USA University of Toronto, Canada** Insight SFI and Dublin City University, Ireland **Roadscanners Ltd., Finland** IT Center for Scientific Computing (CSC), Finland