River Ice Jam Flood Monitoring and Flood Damage Assessment

Latvian Environment, Geology and Meteorology Centre

Forecasting and Climate Department

Date of Issue: 14.11.2025.
Status: In Review

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D2.1 Material for informing customers

Relevence

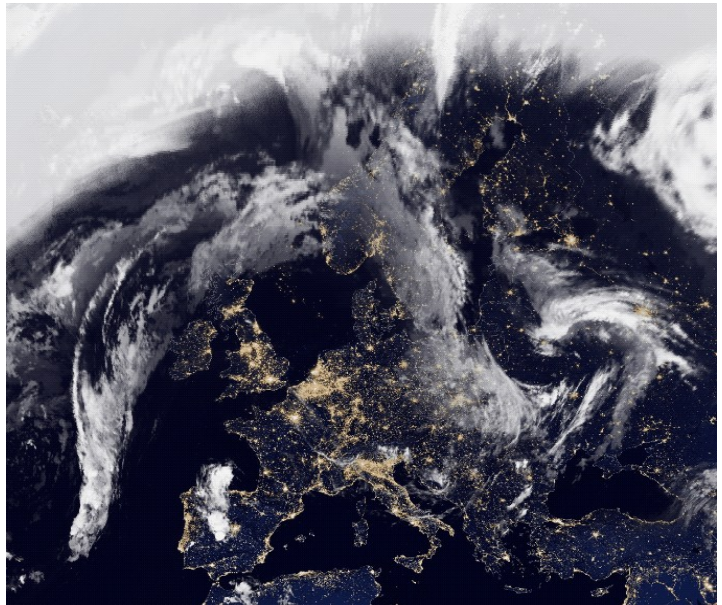
- Due to climate change, the **winter months** in the Baltic region have become more unstable, with **rapid fluctuations in air temperature**
- Air temperature fluctuations promote the **formation of river ice and ice jams**, which in turn cause **sudden, destructive floods**
- Latvia's largest rivers, such as the Daugava, are particularly exposed to these risks, **endangering infrastructure and residents**
- Current monitoring solutions (hydrological stations, webcams installed along riverbanks) do not provide a complete overview of ice conditions in the rivers

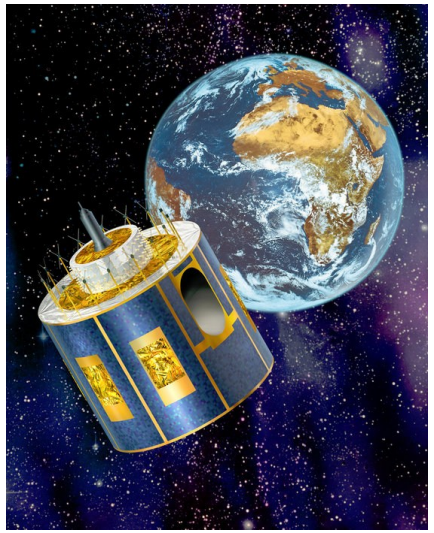
https://www.jekabpils.lv/lv/jaunums/turpinas-ledus-un-viznu-blivesanas-daugava-pie-jekabpils
https://www.delfi.lv/193/politics/56371134/daugava-pie-jekabpils-sacis-iet-ledus

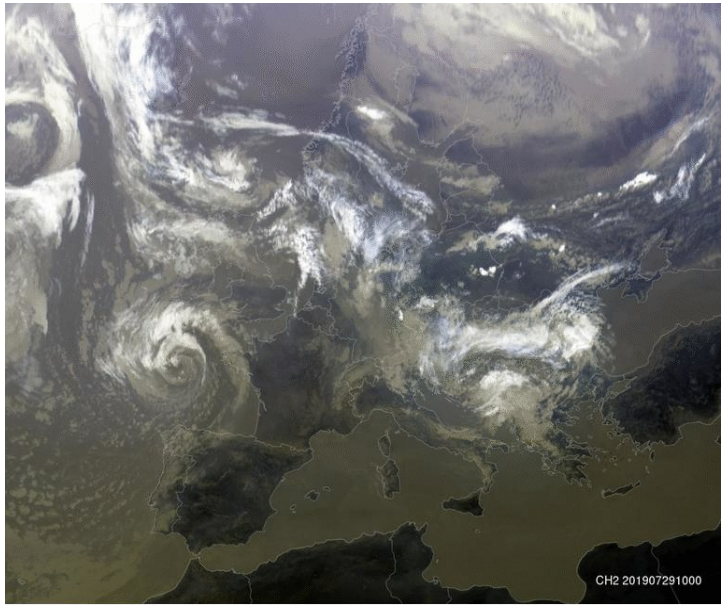
Relevence

Current monitoring solutions do not provide a complete overview of river ice conditions

A more comprehensive view, with wider spatial coverage, can be provided by **remote sensing (satellite) datasets**







Development of a new system

Thanks to financial and expertise support from the **European Space Agency**, from September 2025 to December 2026, a system for detecting **river ice, ice jams, and floods** is being developed using **Sentinel-1 SAR satellite data.**

The system is being developed by the Latvian Environment, Geology and Meteorology Centre in collaboration with partners from the Jēkabpils Municipality and the State Fire and Rescue Service.

Valsts ugunsdzēsības un glābšanas dienests

JĒKABPILS NOVADS

LATVIJAS VIDES, ĢEOLOĢIJAS UN METEOROLOĢIJAS CENTRS

Total project cost: 121 627 €

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Main Activities

Main project **activities**:

- **Study of ice, ice jam, and flood events** in the Daugava River
- Development of an automatic satellite data processing and **visualization system**
- Inclusion of additional rivers in the platform
- **Implementation of flood and flood damage forecasting algorithms** based on the set of algorithms developed under the European Union's Horizon Europe grant agreement No. 101093864, project "CLIMAAX"

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Why Daugava?

- In the municipalities along the Daugava River, floods caused by ice jams have resulted in significant **damage to buildings and critical infrastructure**, as well as **endangering public safety**
- In 2023, floods occurred in the Jēkabpils area with a probability of once in 143 years. A mandatory evacuation was declared, the event was recognized as a **regional disaster, affecting 450 households and causing total losses of 4 313 122 €**.

https://www.la.lv/foto-video-udens-limenis-daugava-pie-jekabpils-tuvojas-devinu-metru-atzimei

https://www.jekabpils.lv/lv/jaunums/turpinas-ledus-un-viznu-blivesanas-daugava-pie-jekabpils

Remote Sensing

Copernicus Sentinel-1 SAR Satellite

- **Copernicus** is the European Union's Earth observation program, operating with six satellites and providing a wide range of applications
- The **Copernicus Sentinel-1 SAR** is a European radar observation satellite, the first of five missions providing information services in the fields of environment and security
- The active space radar allows observations under **any weather conditions, day and night**, acquiring measurement data at **high and medium resolution on land, coastal areas, and ice conditions**

Copernicus Sentinel-1 SAR Satellite
Photo: European Space Agency

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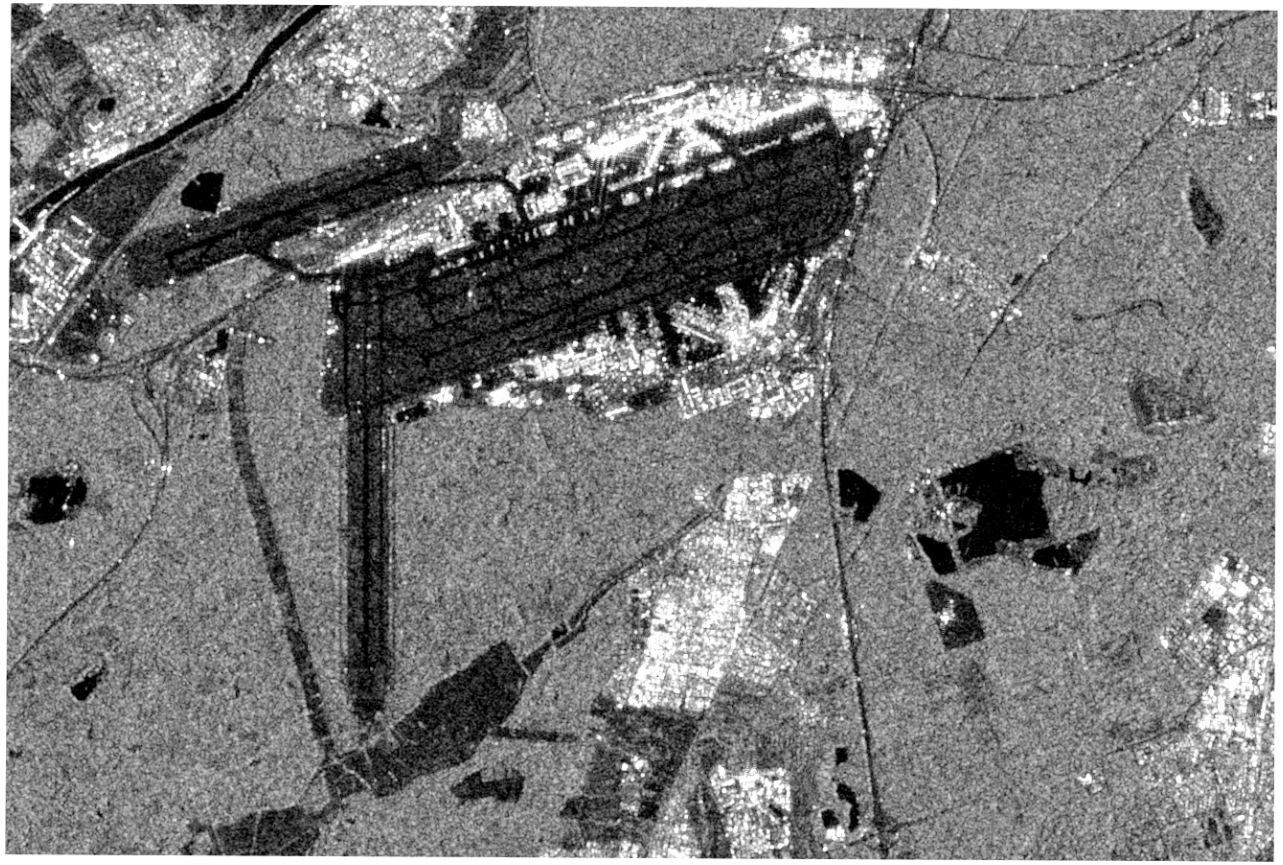
Remote Sensing

Copernicus Sentinel-1 SAR Satellite

The Sentinel-1 satellite constellation consists of two C-band synthetic aperture radar satellites (VV/VH polarization) in sun-synchronous polar orbit

Thanks to these satellites, we obtain:

- Repeat observation frequency: **2–6 days** (1–3 days in some areas)
- **5 × 5 meter** spatial resolution
- Global data coverage



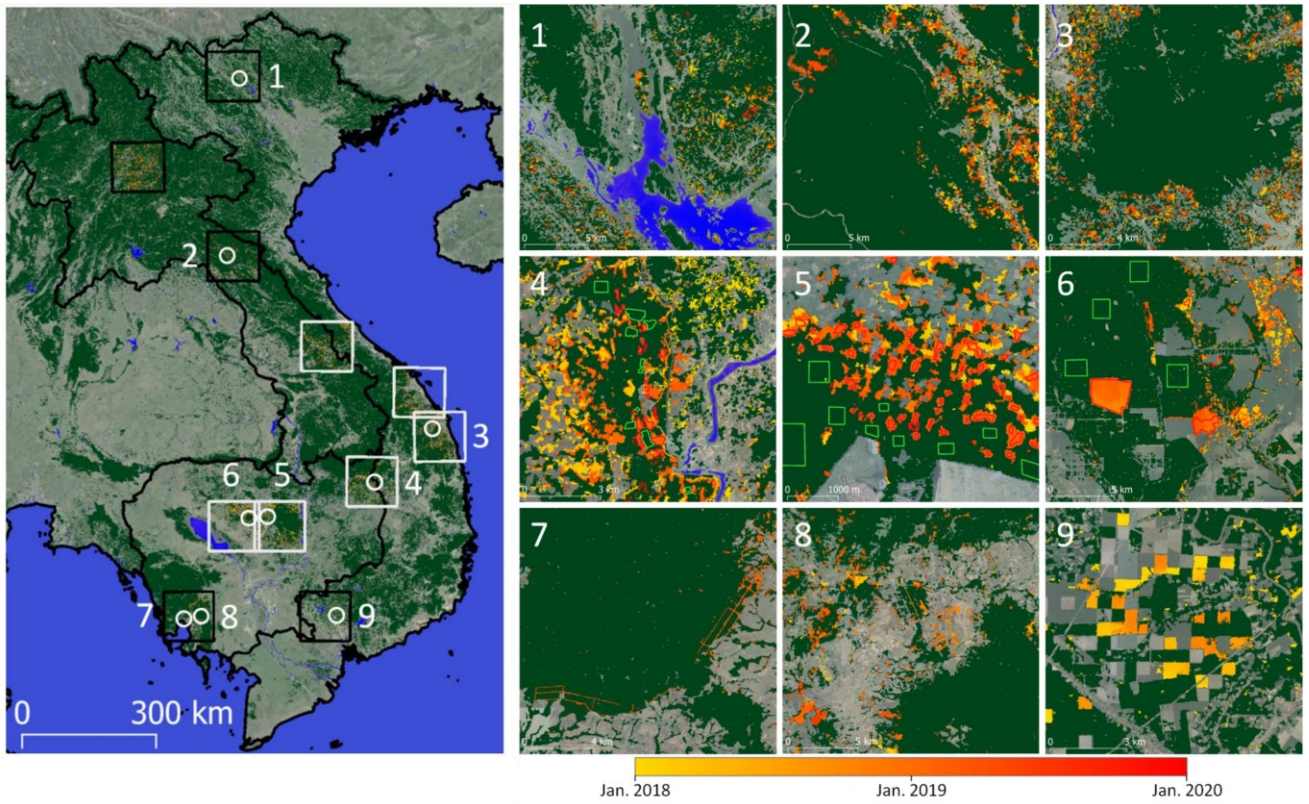
Copernicus Sentinel – 1 SAR image of Frankfurt Airport
Photo: European Space Agency

Remote Sensing

Copernicus Sentinel-1 SAR Satellite

Applications in the Economy:

- **Agriculture:** Identification of crop types, assessment of their condition, determination of soil moisture
- **Forestry:** Biomass assessment, species identification, wildfire monitoring
- **Hydrology:** Monitoring of wetlands and snow cover
- **Oceanography:** Sea ice detection, coastal wind field measurements, oil spill detection
- **Security:** Detection and classification of ships



Forest wildfire detection using Copernicus Sentinel-1 SAR
Photo: European Space Agency

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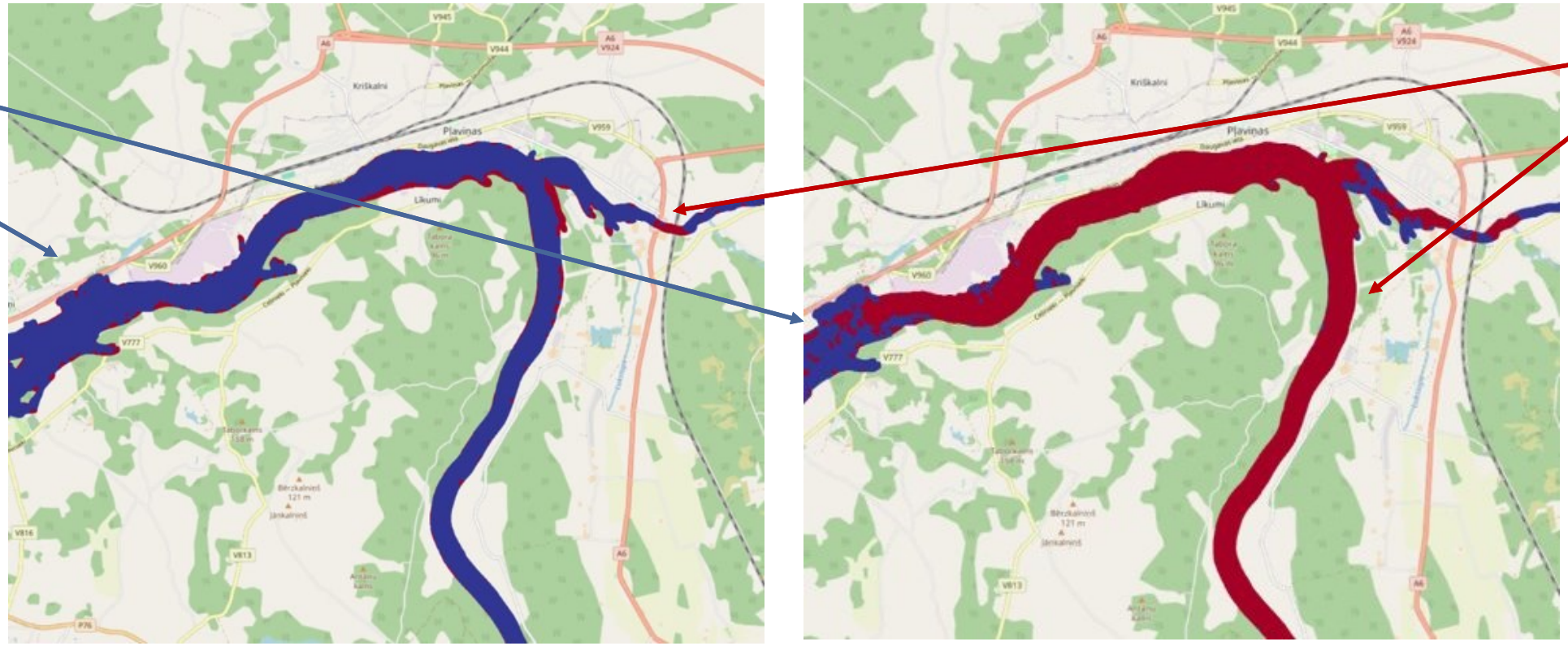
River Ice Detection

To obtain an image clearly showing ice jams and river floods, a set of algorithms is applied, based on research developed in Lithuania (E. Stonevicious et. al., 2022).

Blue color indicates water

Red color indicates ice



Processed Sentinel-1 satellite data in the Pļaviņas area 14.01.2024. and 16.03.2024.

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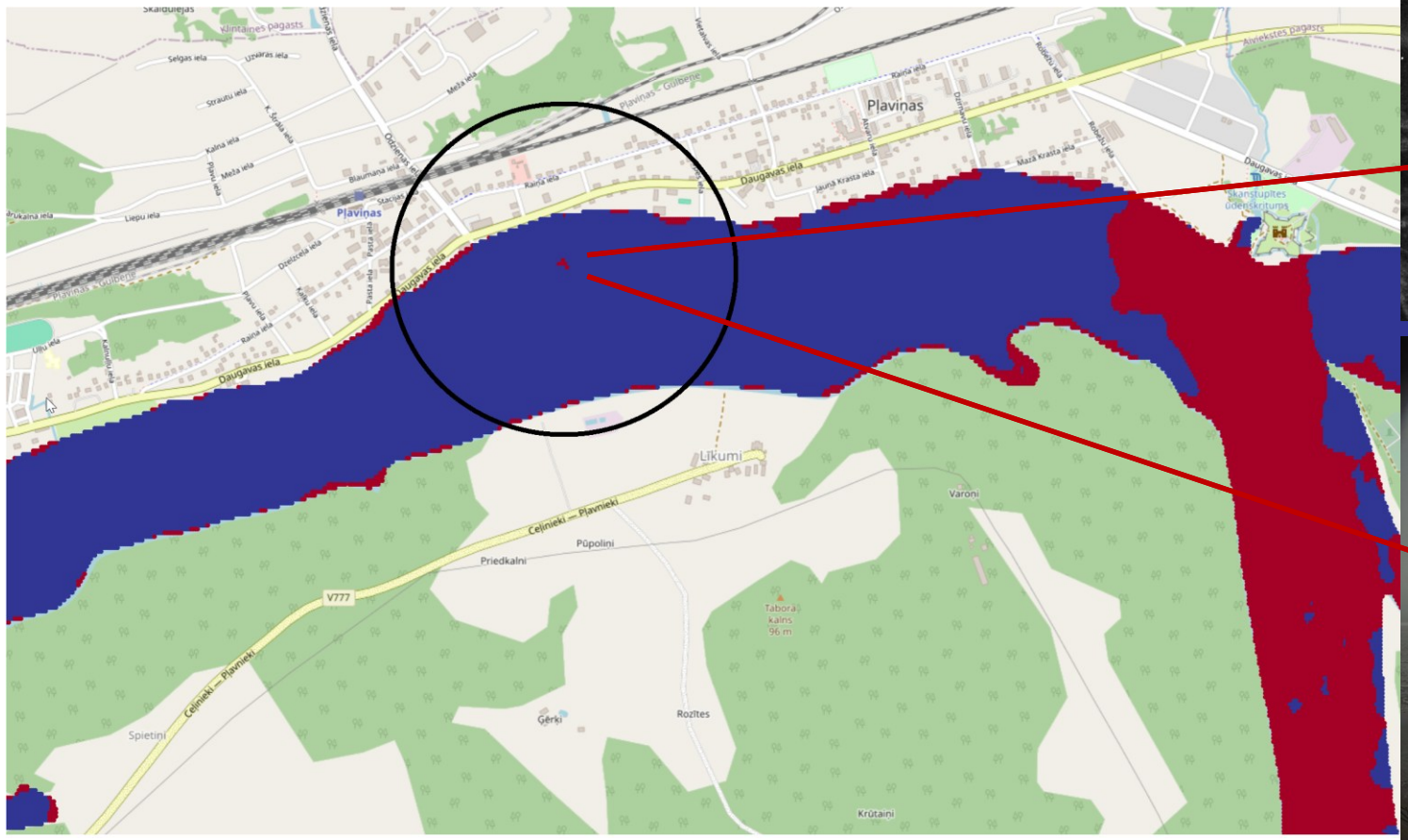
River Ice Detection

The algorithm detected an ice block located near an LEGMC webcam, allowing it to be verified



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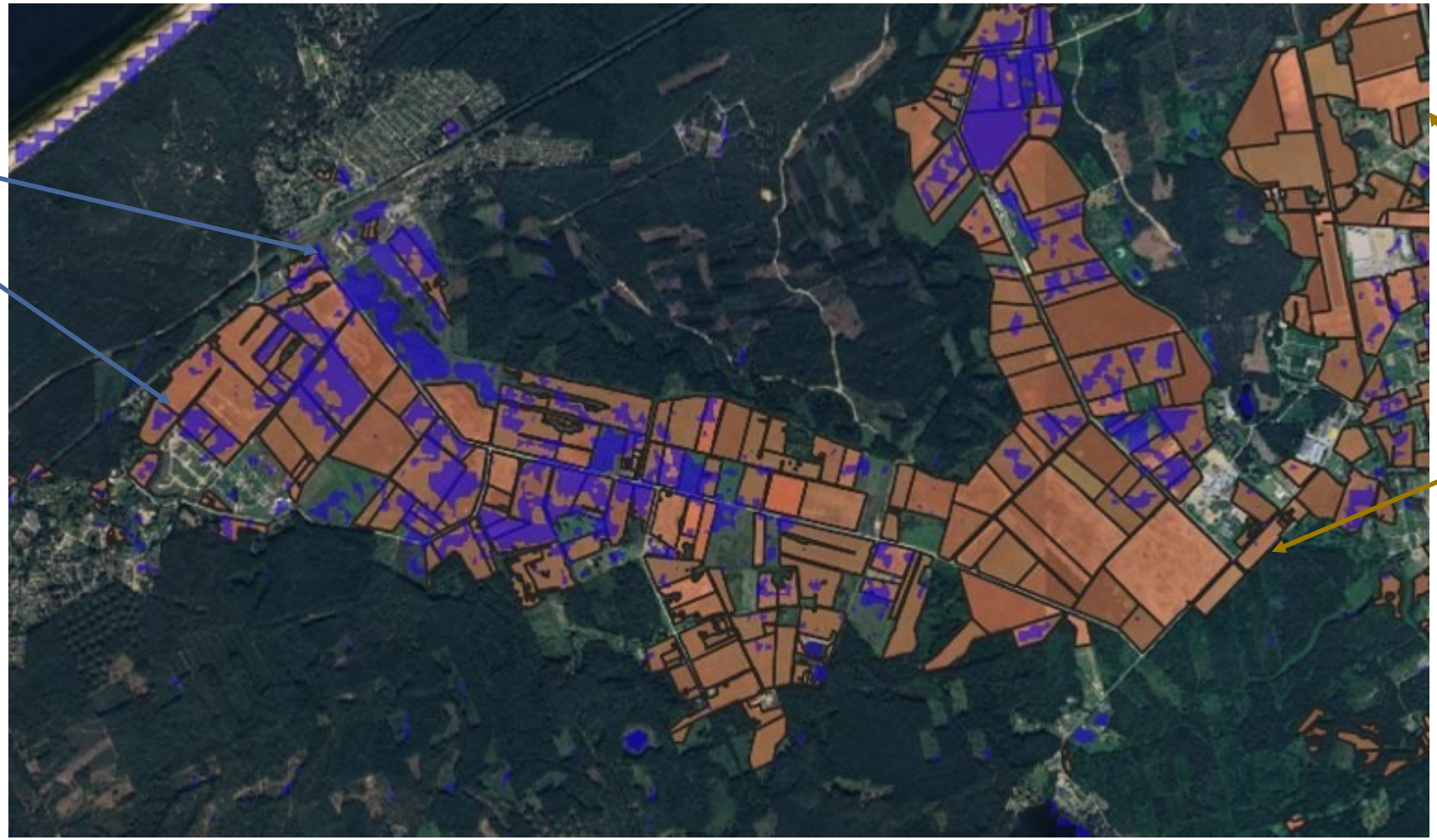
Detection of Water-Covered Areas

Blue color indicates water



Brown color indicates agricultural areas

Processed Sentinel-1 satellite data near Carnikava 02.01.2023.

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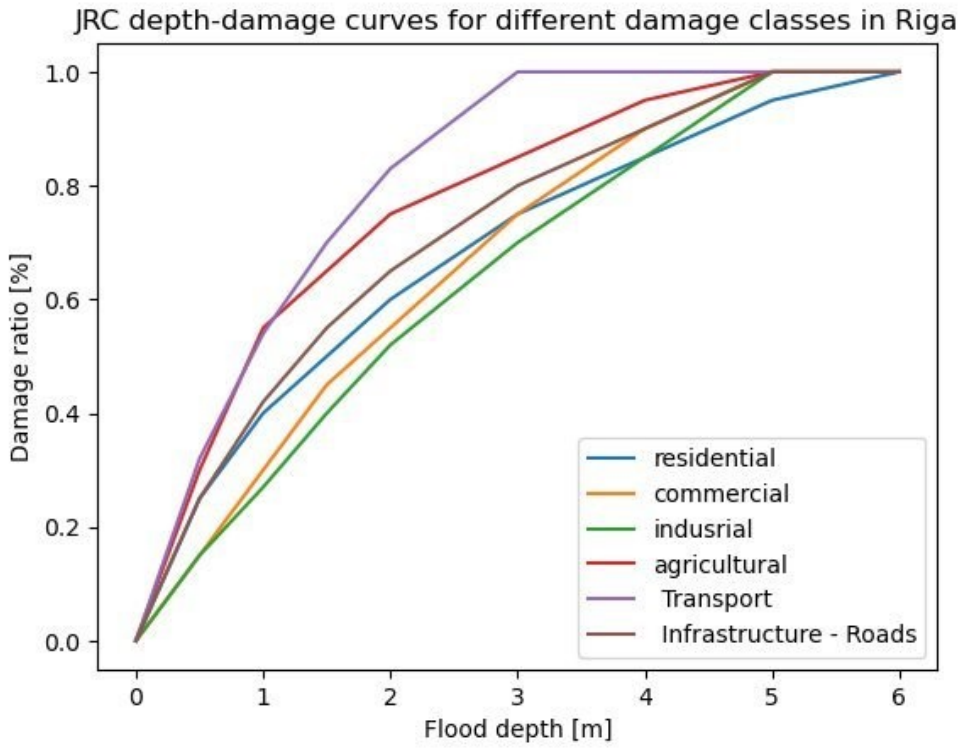
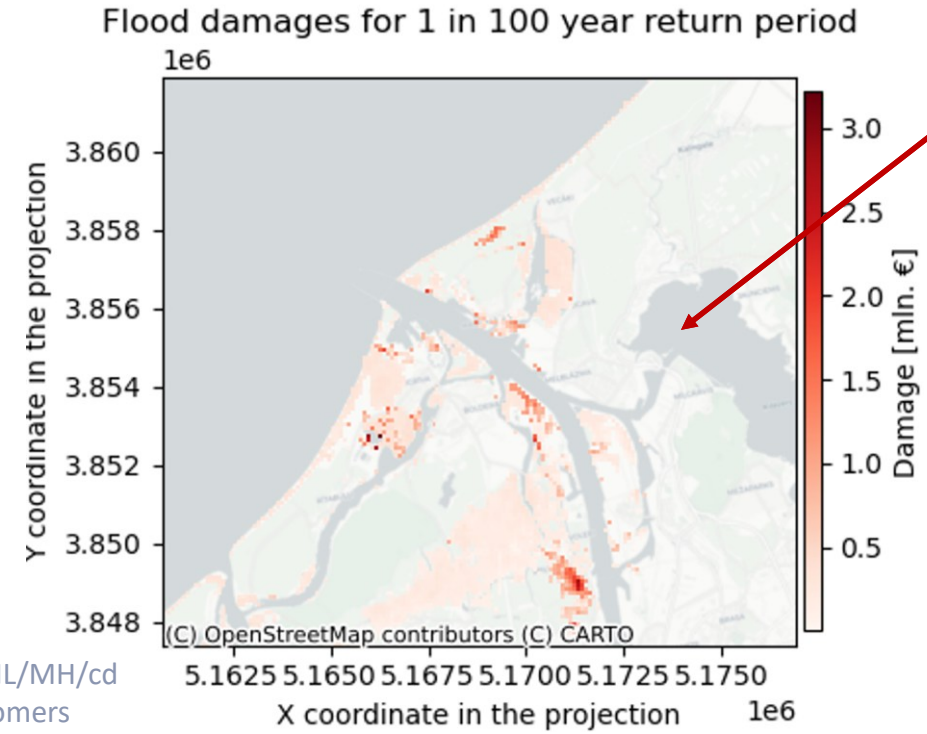
Assessment of Potential Losses

Potential losses can be assessed using the set of algorithms developed under the Horizon Europe project "**CLIMAAX**"

CLIMA**te risk and vulnerability **A**ssessment framework and toolbo**X





Visualization of the results from the set of algorithms developed by the project for Riga

CLIMAAX
climate ready regions

Newly Created Platform
for River Ice, Ice Jam, and Flood Detection

Thanks to the newly created system, clients will have the opportunity to use a platform consisting of:

- **Real-time Copernicus Sentinel-1 SAR satellite imagery** capable of detecting rivers and water and ice-covered areas, as well as flood conditions
- **A historical data archive** with imagery from the mentioned satellite
- **Maps** illustrating the potential losses in flooded areas
- **Supporting materials** for developing hydrological forecasts

LVĢMC

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sentinel-1

Thank you!

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opernicus
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CLIMAAX
climate ready regions

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