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Early warning Demonstration of pan-European rainfall-induced impact forecasts

Co-funded by the European Union

EDERA Convective Hazard and Impact Nowcast Products

Centre de Recerca Aplicada en Hidrometeorologia
UNIVERSITAT POLITÈCNICA DE CATALUNYA

ECMWF

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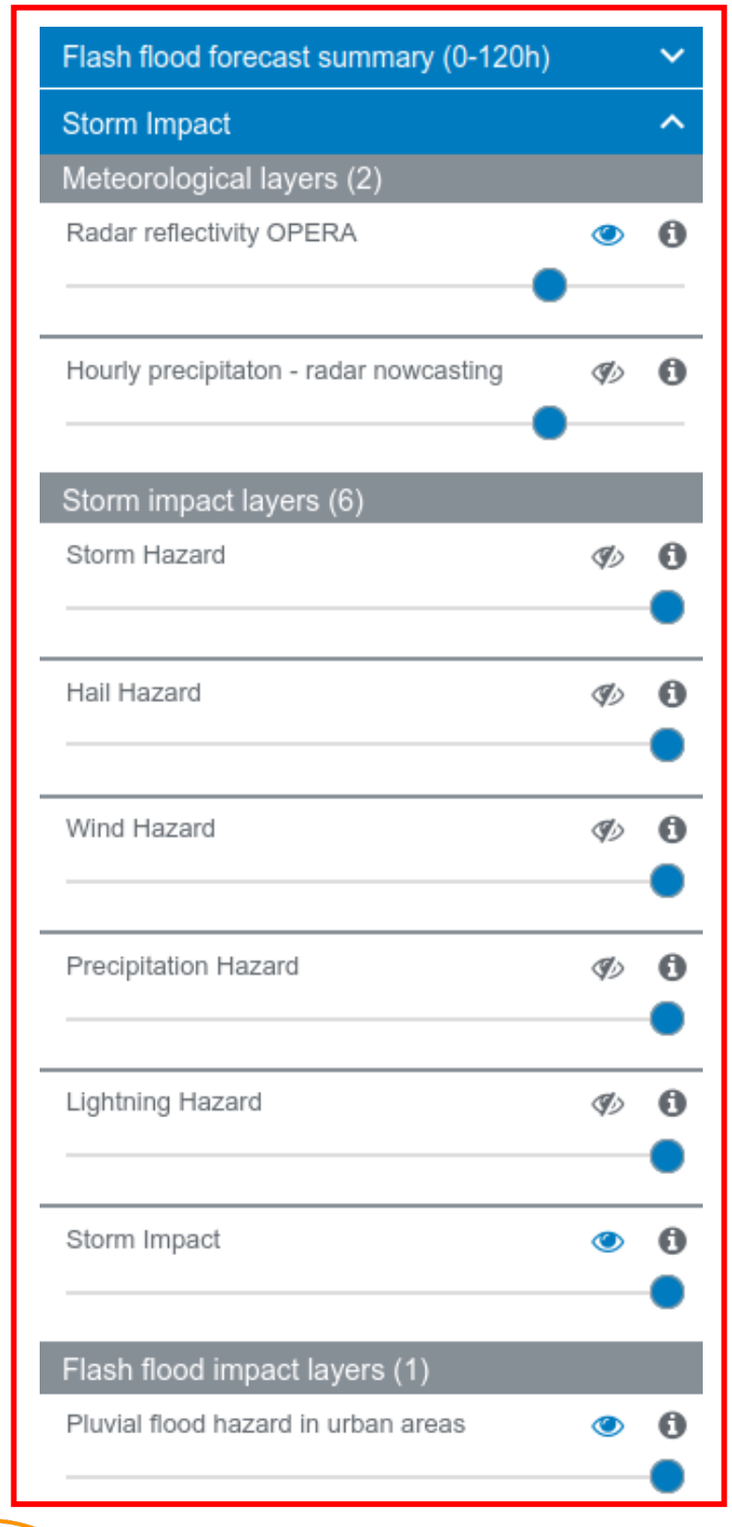
Agencia de Medio Ambiente y Agua de Andalucía
Consejería de Agricultura, Pesca, Agua y Desarrollo Rural
Consejería de Sostenibilidad, Medio Ambiente y Economía Azul

GOBIERNO DE ESPAÑA
MINISTERIO DEL INTERIOR
DIRECCIÓN GENERAL DE PROTECCIÓN CIVIL Y EMERGENCIAS

EMERGÊNCIA E PROTEÇÃO CIVIL
AUTORIDADE NACIONAL

EDERA Storm Impact Layers



Meteorological layers:
- Radar reflectivity (OPERA)
- Hourly rainfall accumulation nowcast

Purpose: forecasts of instantaneous rain rate and accumulated rainfall

Hazard nowcast layers:
- Overall storm hazard level
- Different products for each hazard type

Purpose: provide information about hazard potential of storm cells

Storm impact layer

Purpose: provide the above information weighted by exposure

Flash flood impact layers

Purpose: provide flood warnings to urban areas

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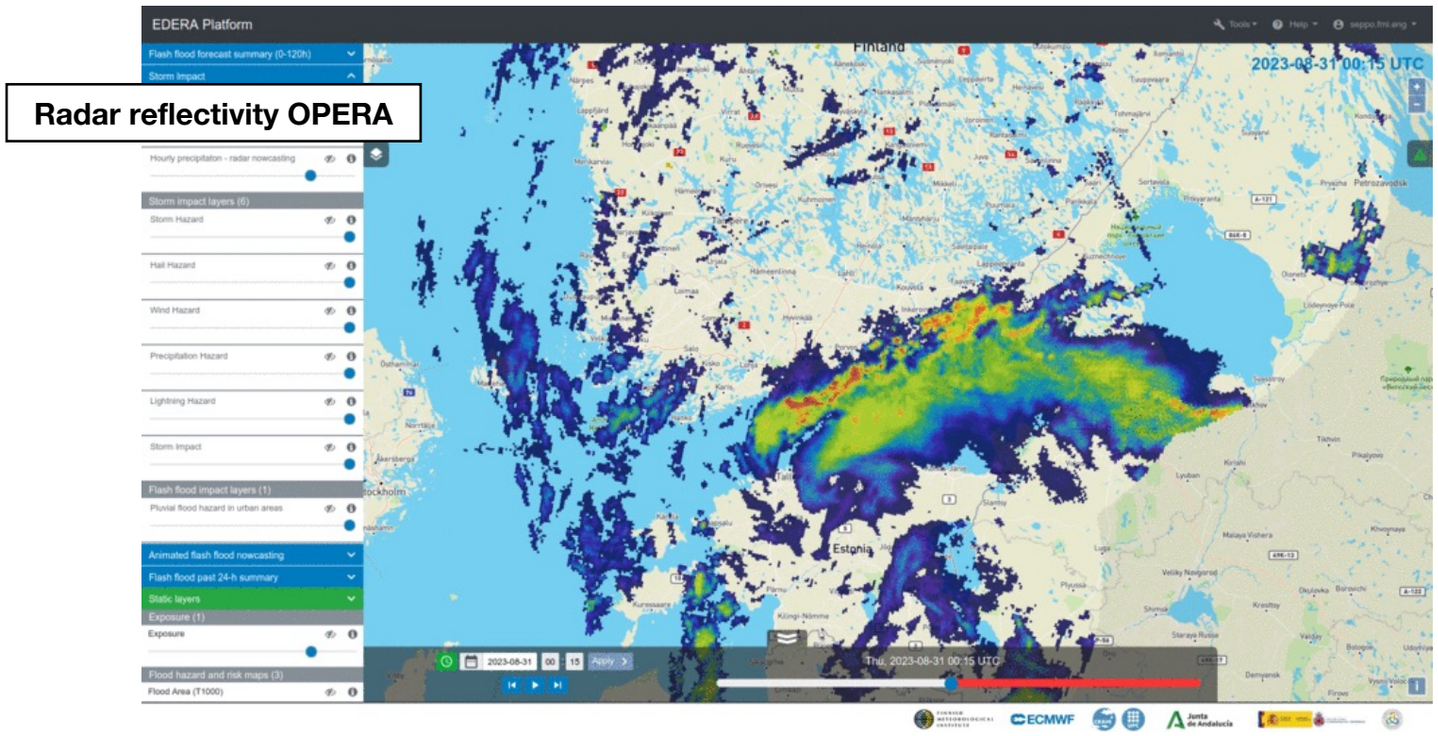
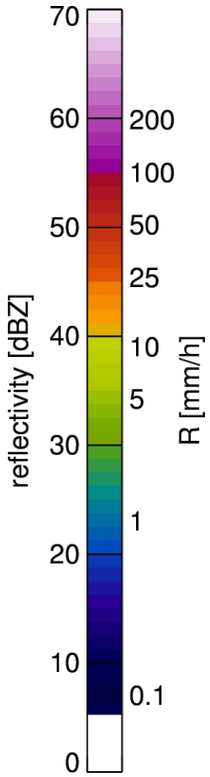
Precipitation Layers

Radar reflectivity OPERA

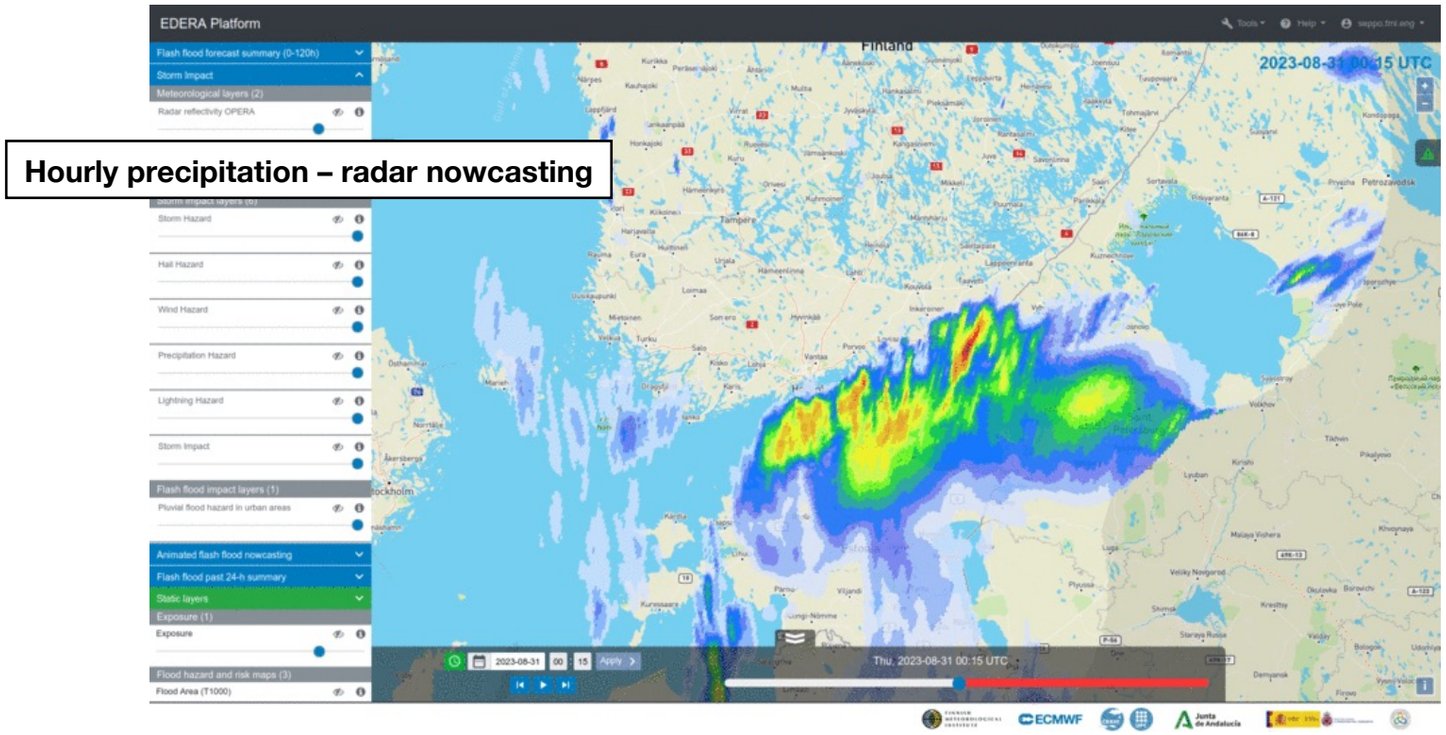


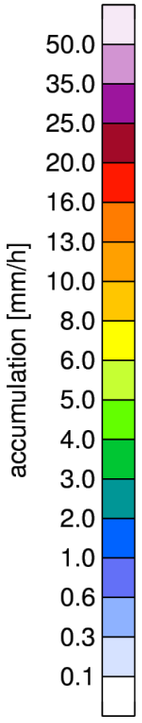


Composite of radar-measured reflectivity values

- Reflectivity is converted to rain rate (mm/h)
- Spatial resolution of 2 km
- Generated every 15 minutes

Hourly precipitation – radar nowcasting





Nowcast of hourly rainfall accumulation

- Generated every 15 minutes by extrapolation of radar images
- Spatial resolution of 2 km
- Forecasts with 15-minute time steps to the next 4 hours

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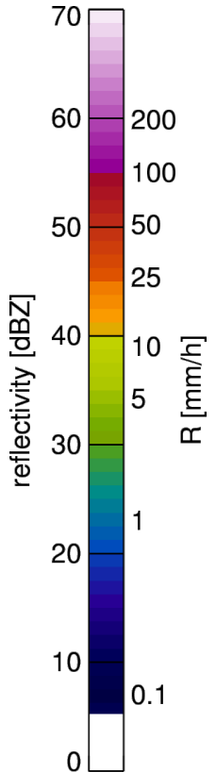
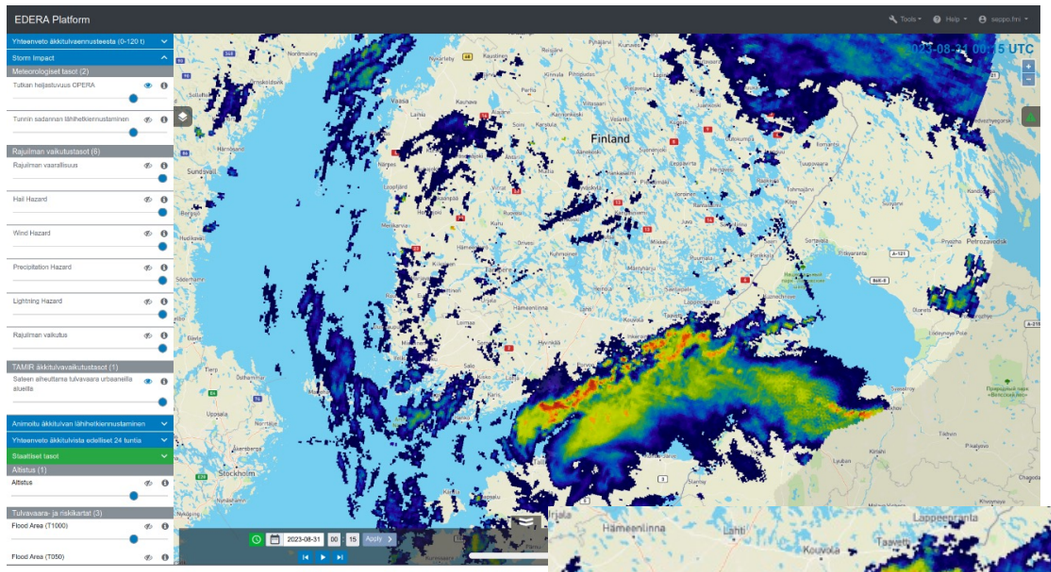
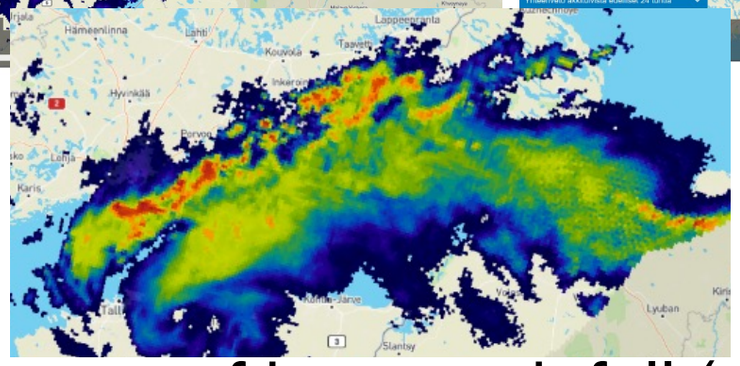
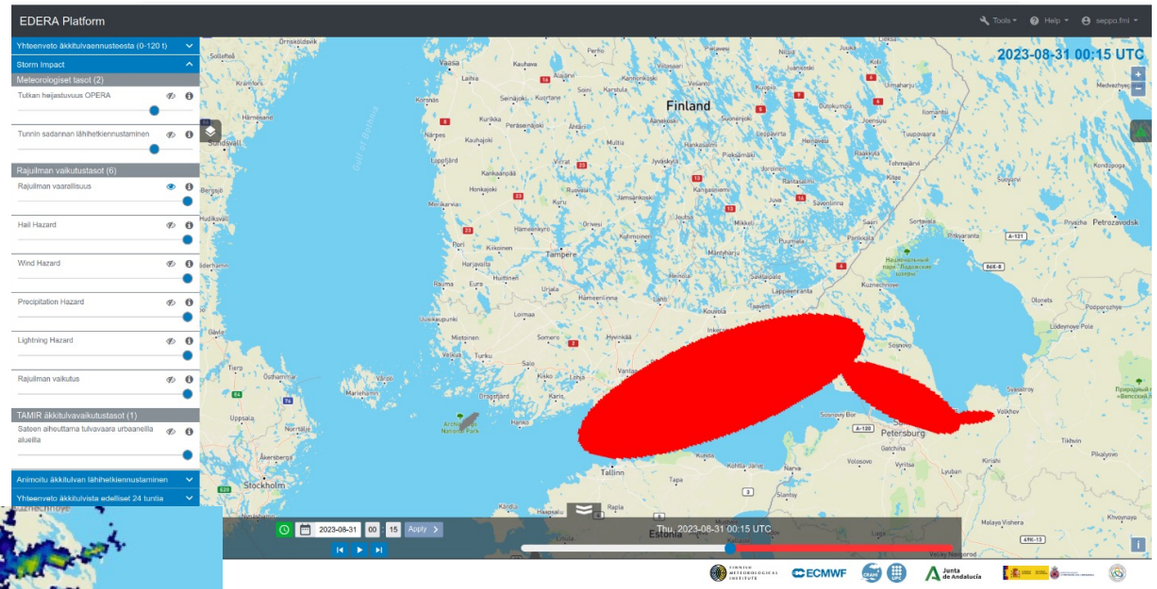
The Combined Hazard Nowcast Layer





Radar reflectivity





Storm hazard

- Ellipses fitted to areas of heavy rainfall (reflectivity over 35 dBZ)
- Each ellipse is assigned a hazard class by using a machine learning model
- 4 hazard categories based on climatological thresholds
- The overall hazard category is the maximum of the 4 sub-categories
- Additional layers for each hazard type

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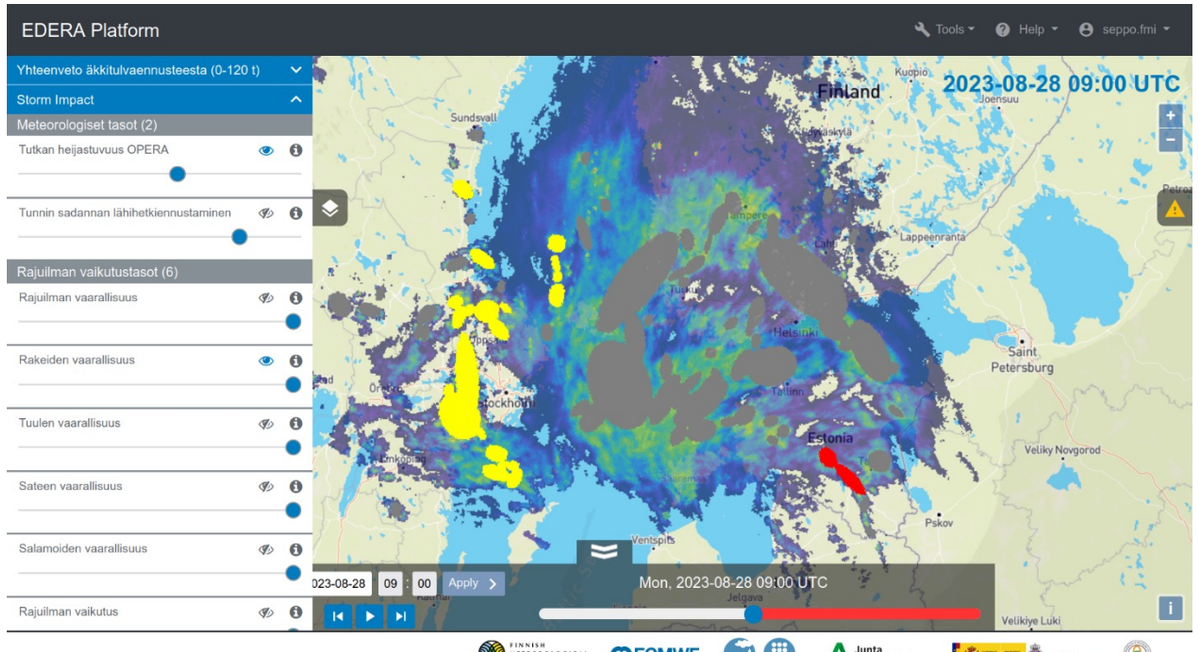
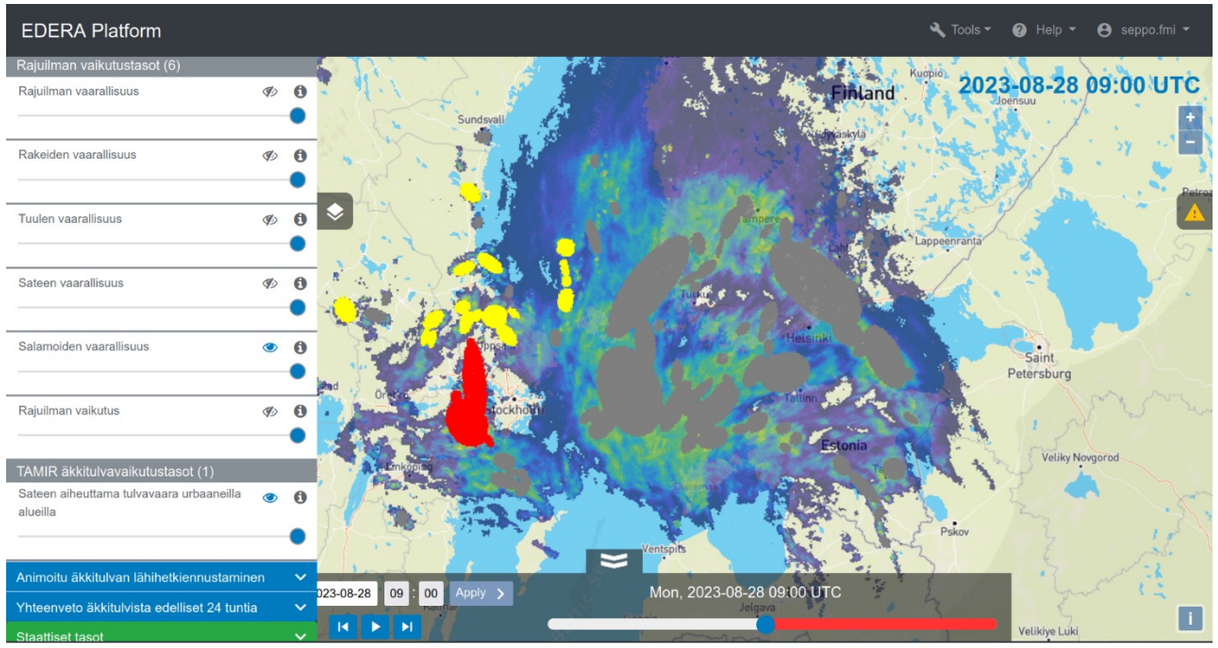
Layers for Different Hazard Types

August 28th 2023

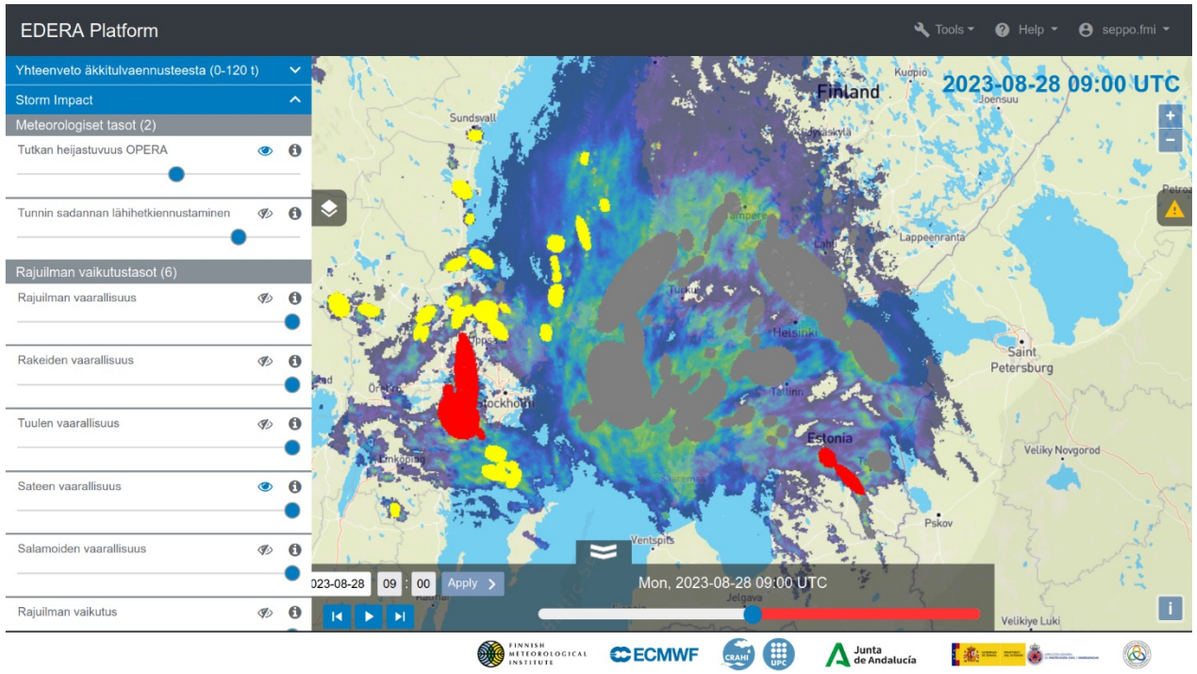
Hail



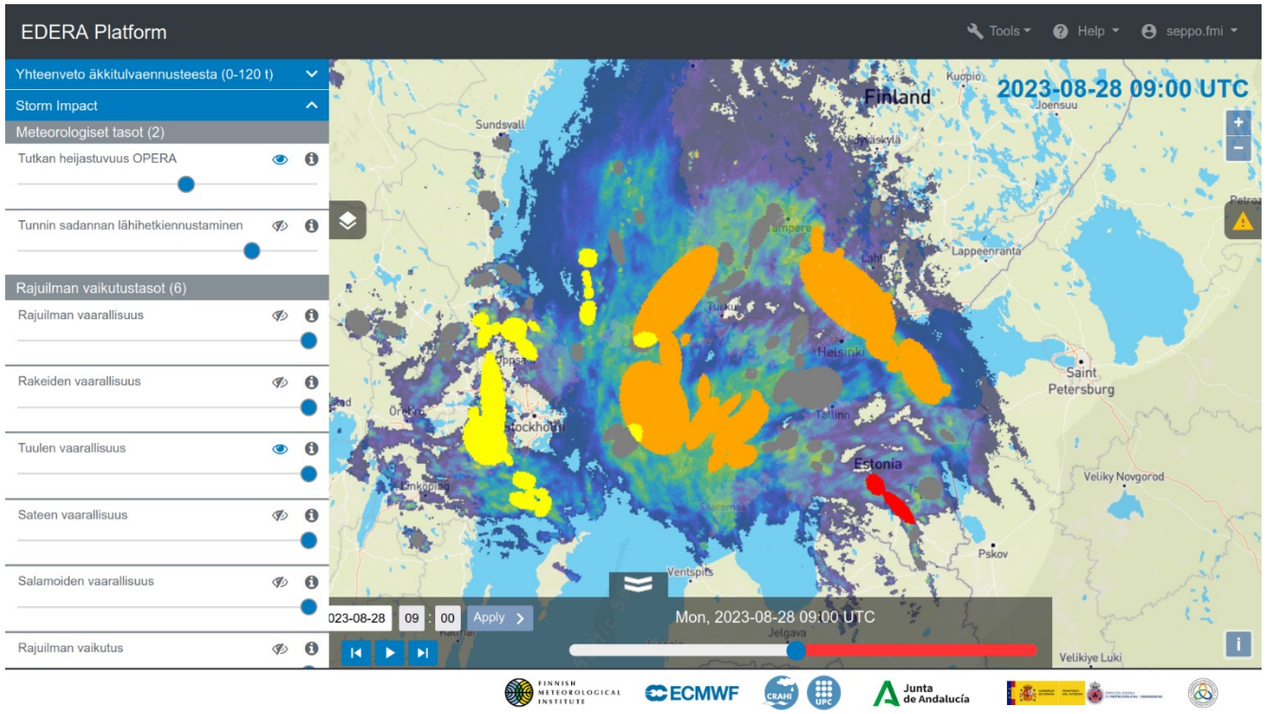
Lightning



Precipitation



Wind



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Separate machine learning models are trained for each hazard type

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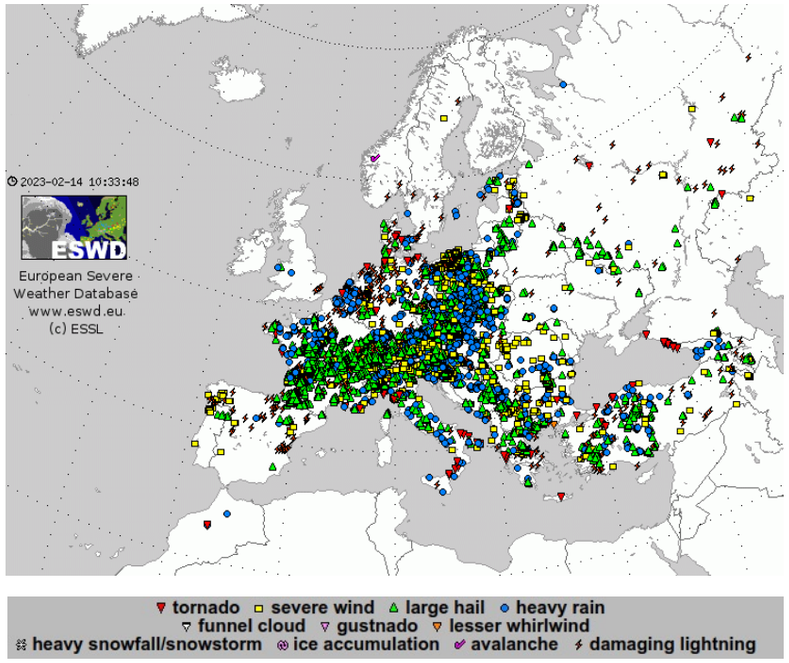
The model for predicting storm hazard levels is trained against the European Severe Weather Database (ESWD) reports →

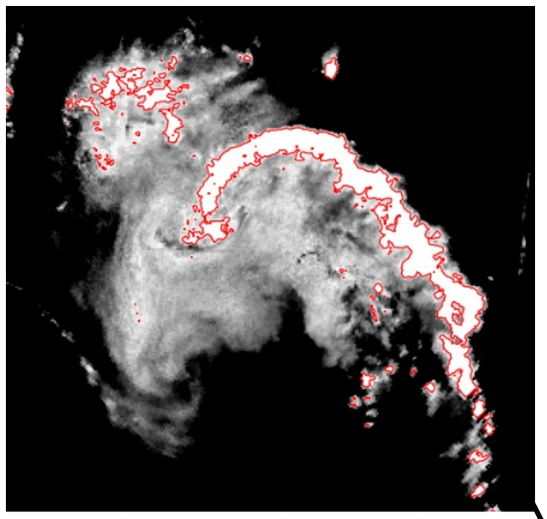


https://eswd.eu

"Trees damaged"

"A House fire was reported due to lightning strike. Around 10 sq. meters of roof were burned, 15 sq. meters damaged."

Storm cells identified from OPERA radar mosaics



Meteorological conditions inside storm cells

Radar mosaics: rain rate, accumulated rainfall

Other meteorological variables (e.g CAPE, CIN)

Machine learning model

Storm hazard levels derived from ESWD reports

Training

Prediction

Predicted hazard levels

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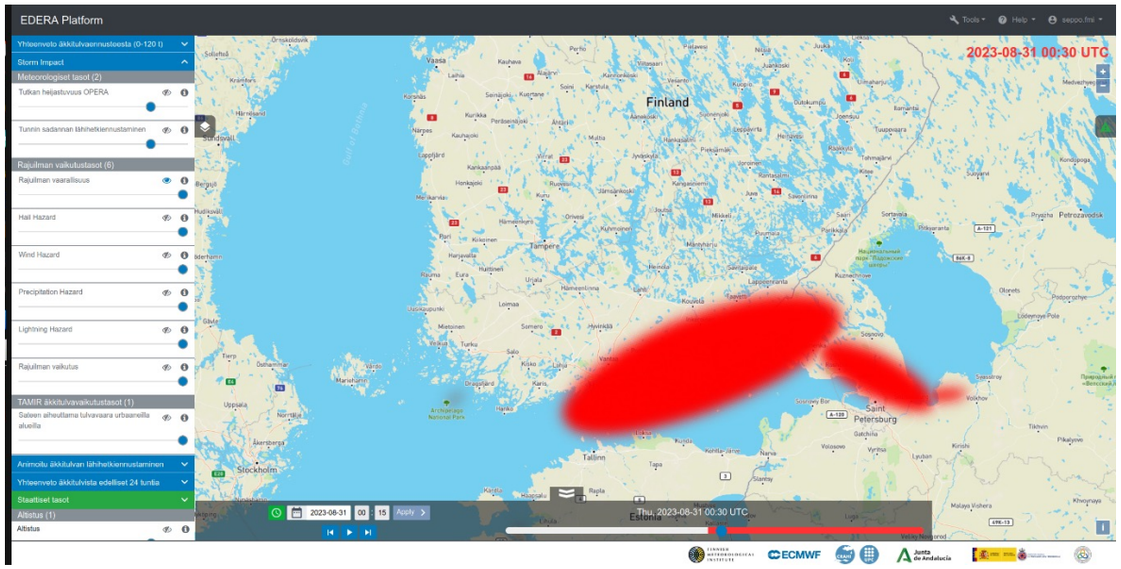
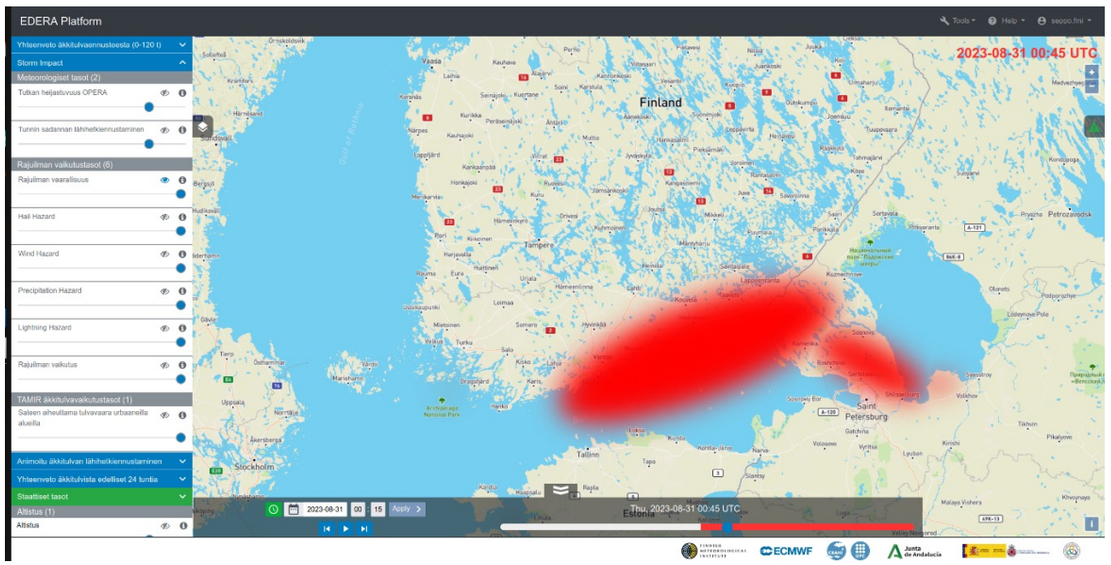
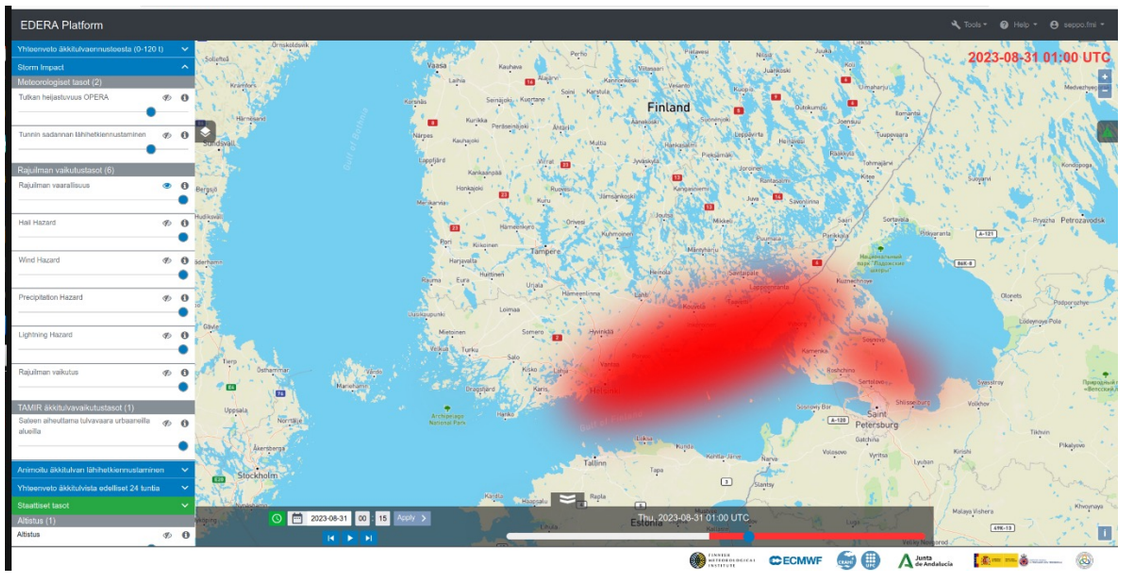
Uncertainty of Storm Location



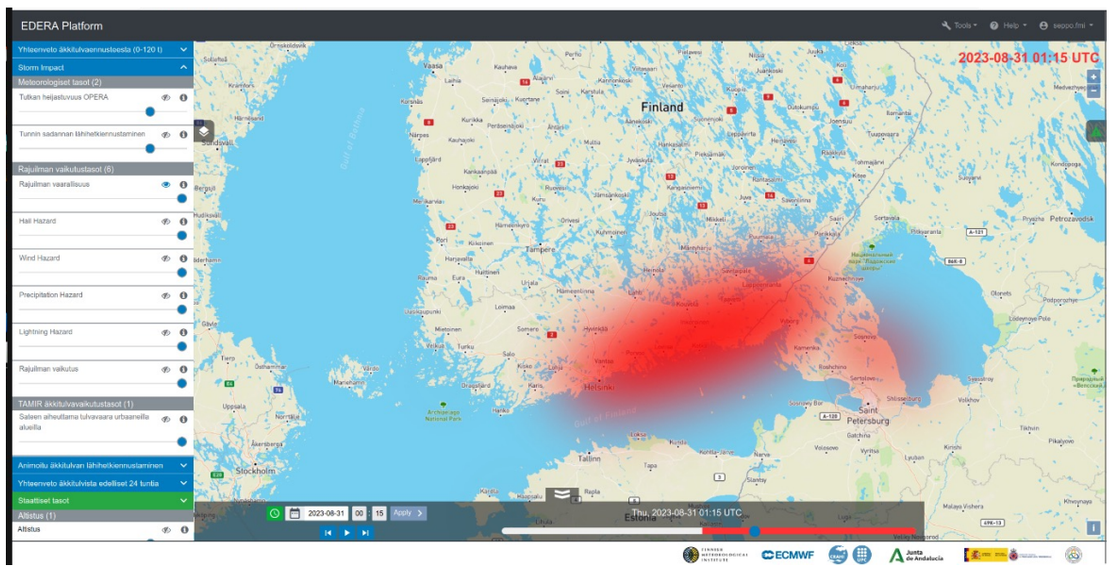
15 minutes



30 minutes

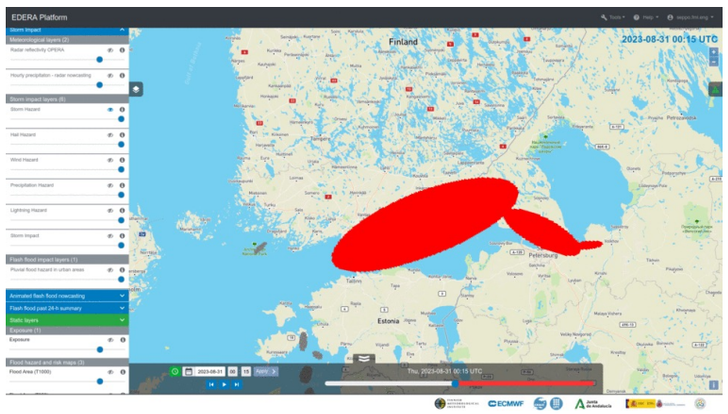


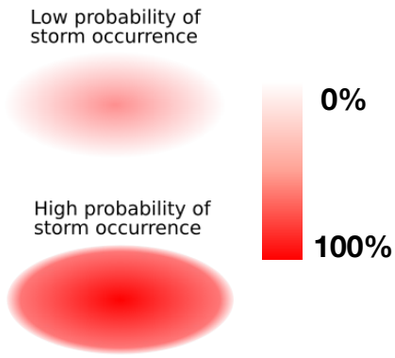
45 minutes



60 minutes

- The nowcast layers show future storm positions
- Storm hazard level does not change during the forecast time window
- Uncertainty in the nowcasts is visualized by increasing spread and transparency of the ellipses





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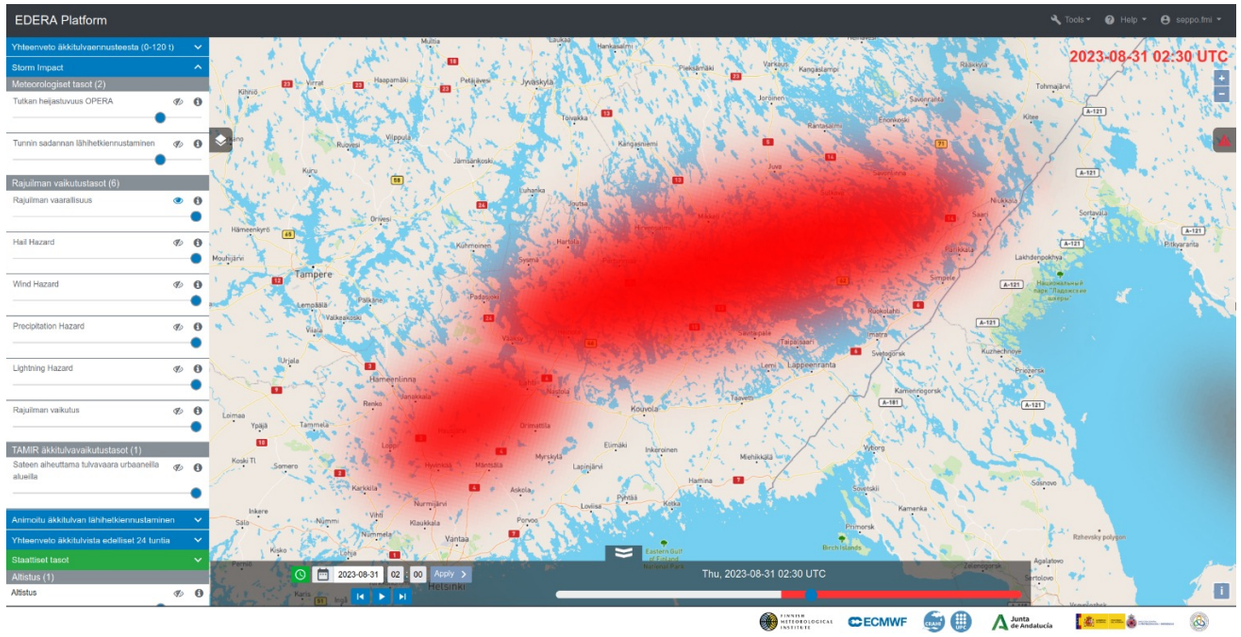
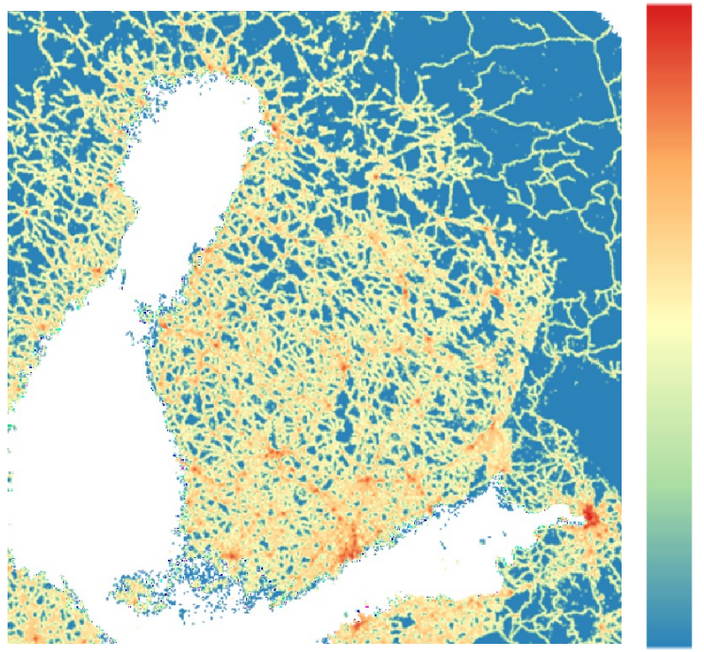
Convective Impact Nowcasts

- Hazard nowcasts are combined with exposure layer to give weight to vulnerable areas
- We use pan-European exposure layer provided by ECMWF
- Exposure data from HARCI-EU and JRC: combination of population, health, education, transport and energy-related exposures



Hazard nowcast

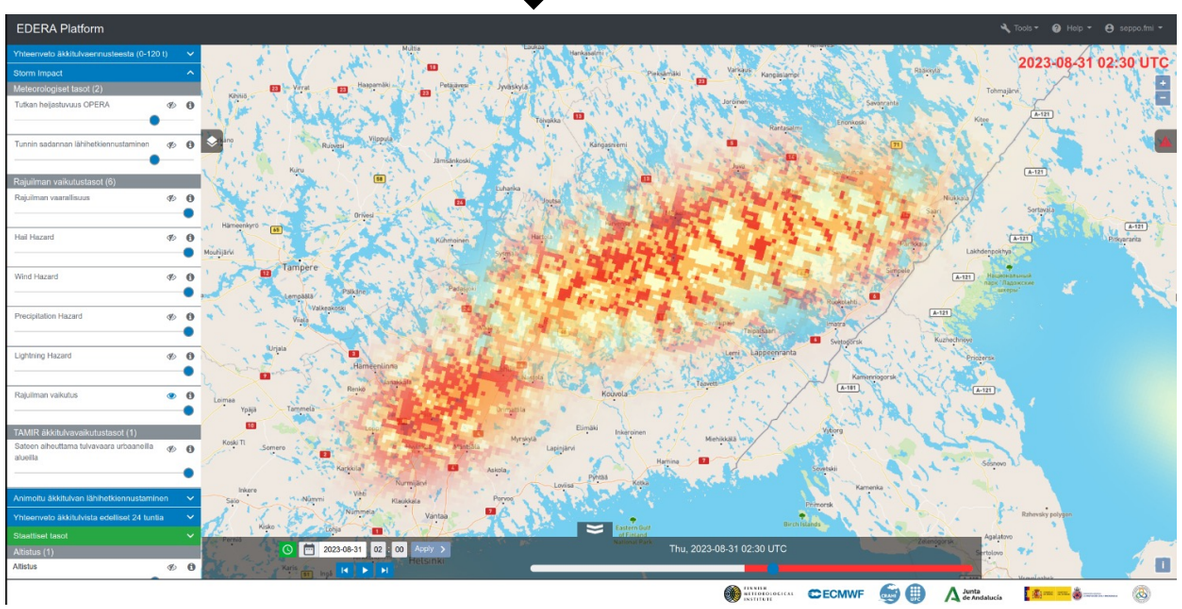
*



High exposure

Low exposure

impact class =
hazard class * exposure class



Impact nowcast

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Guidelines for Using the Storm Impact Layers

- Forecasts are generated 4 hours ahead every 15 minutes
- 2 km spatial resolution

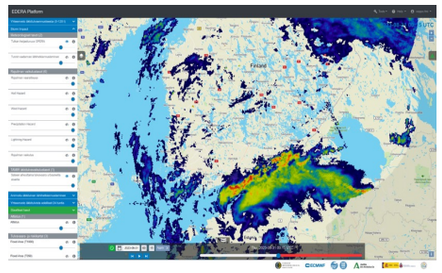
Short-term forecasting of intense storm cells, their hazards and impacts

Storm hazard

Storm impact

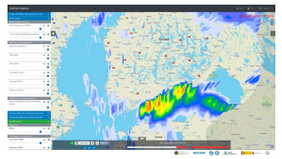
- Shows instantaneous rain rates
- Useful for predicting flash floods

Radar reflectivity OPERA

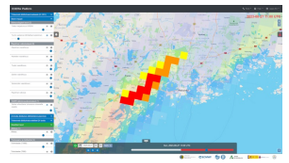


- Shows accumulated rain rates
- Useful for predicting floods that take longer time to accumulate

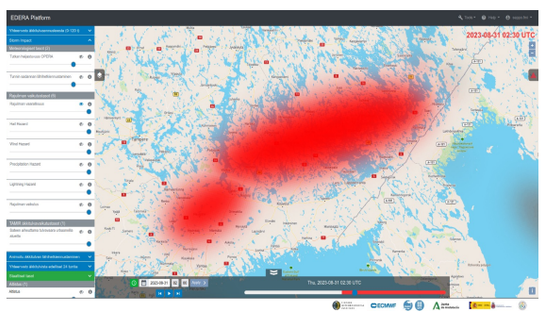
Hourly precipitation – radar nowcasting

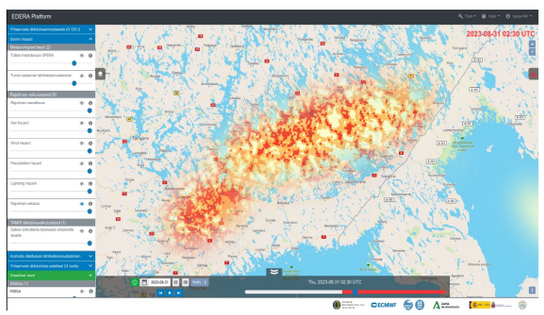


Pluvial flood hazard in urban areas



T+0 h T+1 h T+2 h T+3 h T+4 h





- Based on hourly precipitation accumulation nowcast
- Focus on urban areas

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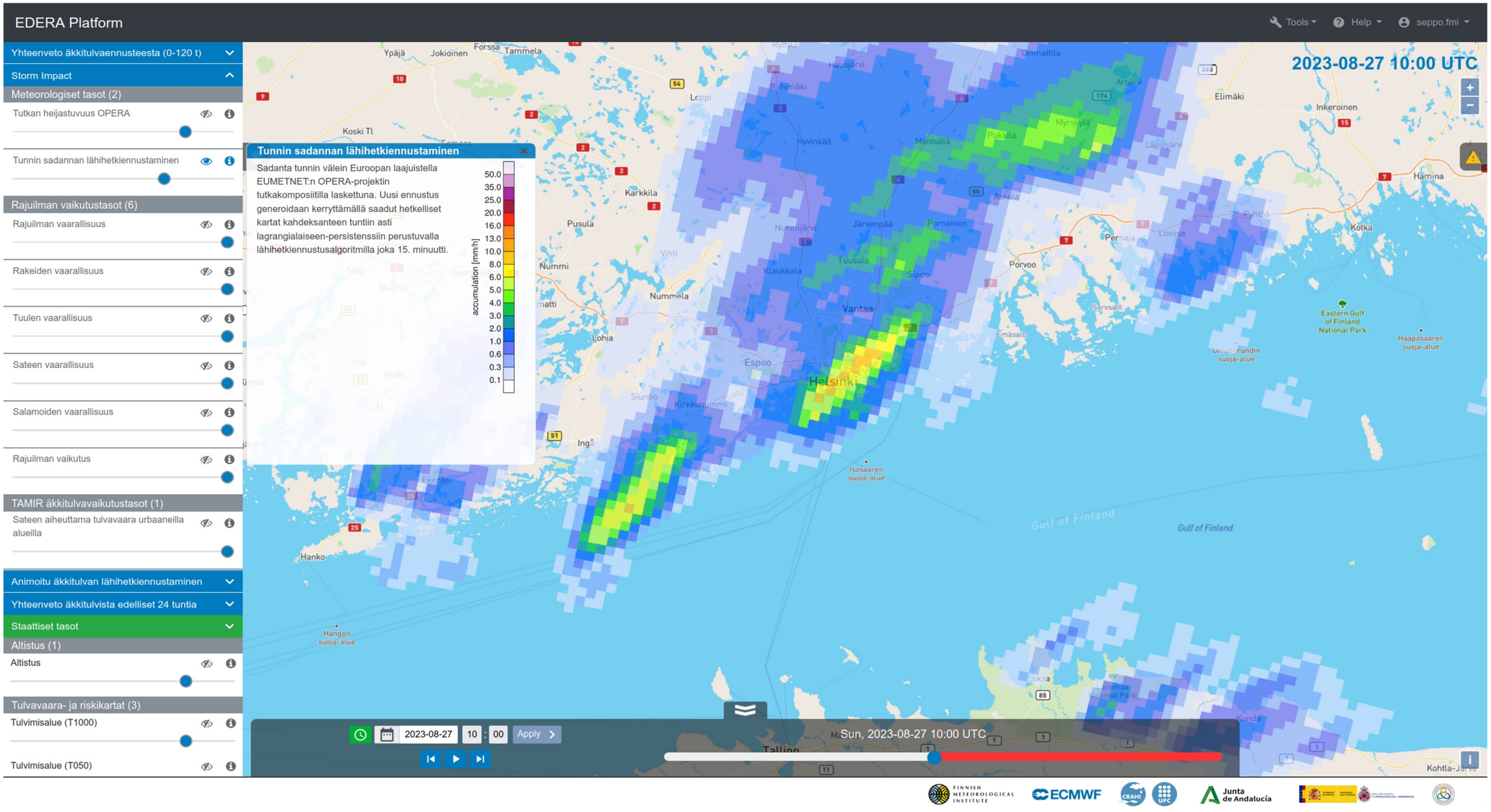
Case Study: Helsinki 27th Aug 2023



Heavy rainfall and flooding in Helsinki in early afternoon

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Workflow

1) Previous day: check official warnings

2) Previous evening: check the latest reflectivity mosaic each hour

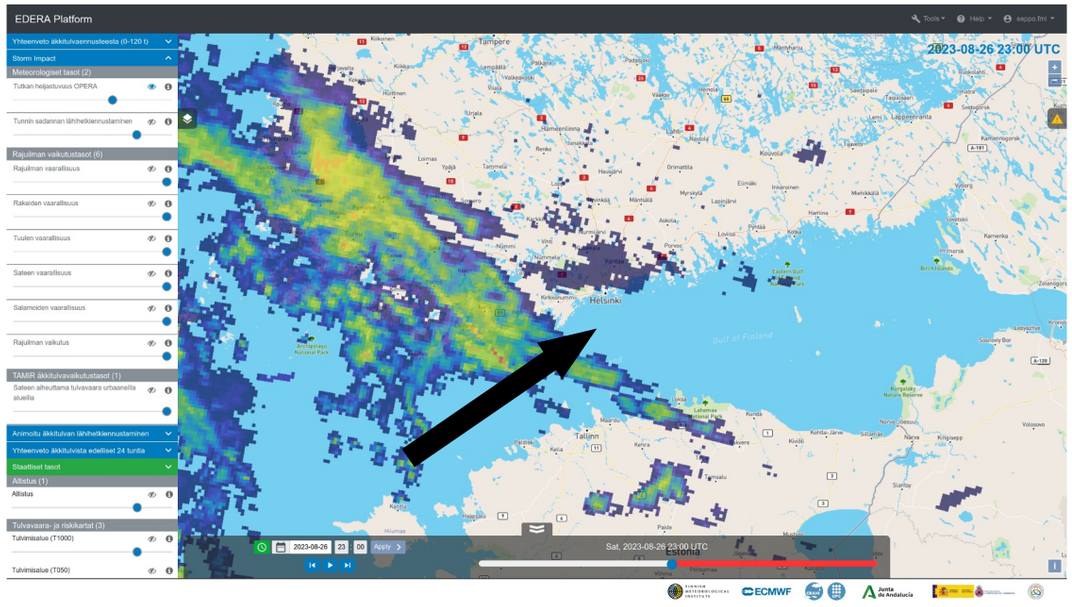
3) 04:00 UTC: the storm is approaching Helsinki. Start checking the storm hazard/impact products every 15-30 minutes.

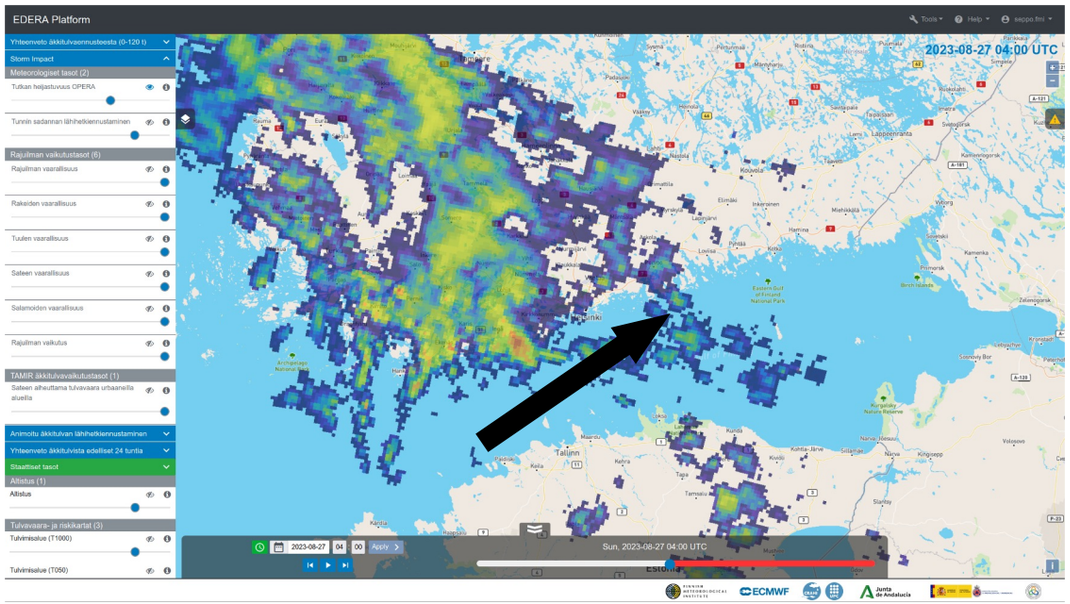
4) 07:00 UTC: Start checking the pluvial flood product together with the hourly accumulation nowcast every 15-30 minutes.

23:00 UTC

OPERA reflectivity mosaic

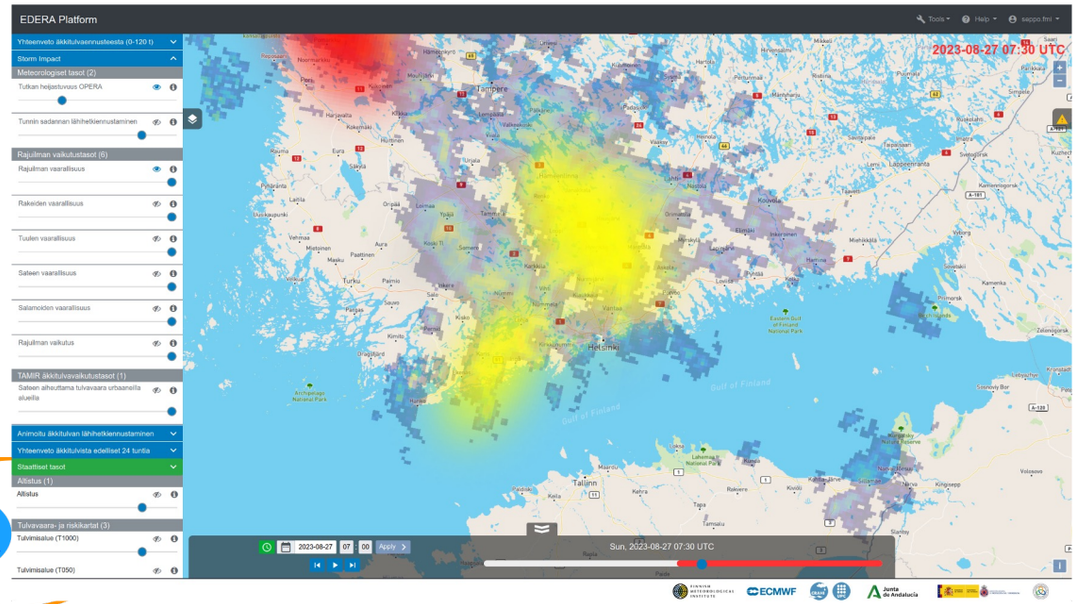
04:00 UTC





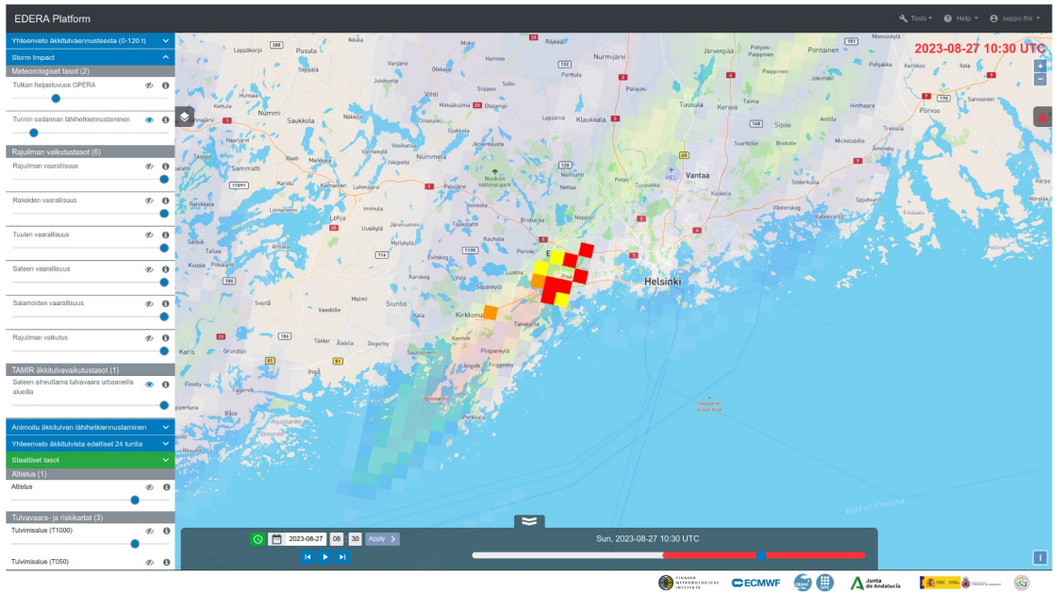
Hazard nowcast

07:00 UTC → 07:30 UTC



Pluvial flood nowcast

08:30 UTC → 10:30 UTC



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