

INLINE – Integrated pan-European rainfall and floods impact forecasts for cooperation in emergency management

Machine learning storm Hazard nowcasting ready for demonstration

Milestone 7

04 August 2026

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Lead Author	Seppo Pulkkinen
Contributors	Heikki Myllykoski
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1 Introduction and scope

This milestone report describes the technical infrastructure and implementation of the machine learning-based storm impact products developed by FMI in task 3.1. These are ready for real-time demonstration. Four different types of products are shown in the INLINE web platform:

1. Nowcasts of precipitation, lightning and wind hazard
2. Nowcasts of precipitation, lightning and wind risk
3. Nowcasts of precipitation intensity produced by using a machine learning model (SimVP)
4. Summary product showing the maximum predicted precipitation risk from above

All products are generated every 15 minutes at 00, 15, 30 and 45 at two-kilometer spatial resolution. The forecast length is next three hours with 15-minute time steps. The corresponding layers in the product selection panel displayed in the INLINE web platform are shown in Figure 1.

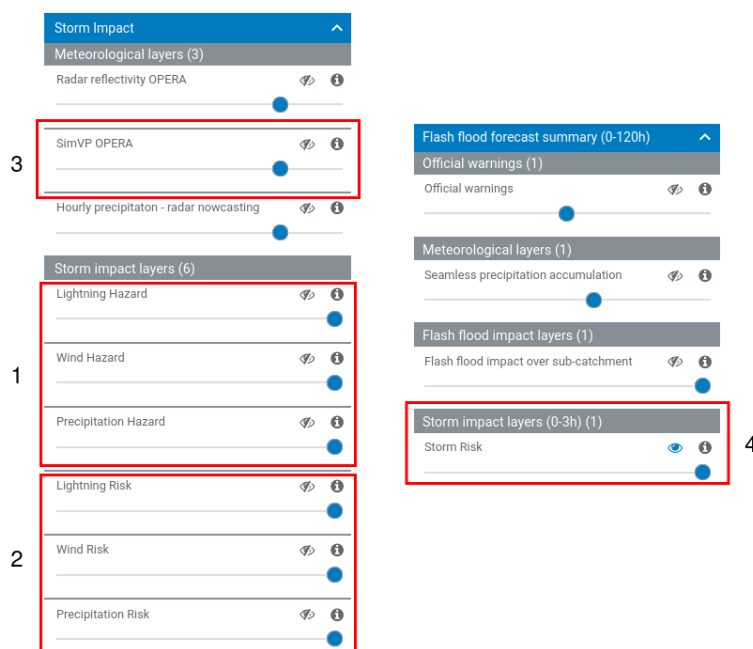


Figure 1 Storm impact products in the INLINE web platform that are developed by the FMI.

2 Overview of product generation

Generation of the storm impact products is done in four stages: 1) generation of nowcasts of meteorological variables (precipitation, wind and lightning); 2) translation of meteorological variables into hazard levels using specified thresholds; 3) further conversion of the hazard into risk by using exposure information; and 4) generation of summary products that give the maximum risk level predicted for the next three hours. Precipitation nowcasts are produced by using a neural network, and flash density nowcasts by simple extrapolation. Wind forecasts are taken from the IFS forecast system operated by ECMWF.

The generated products are stored in GeoTIFF format and are uploaded to the UPC server via FTP. An overview of these steps is shown in Figure 2.

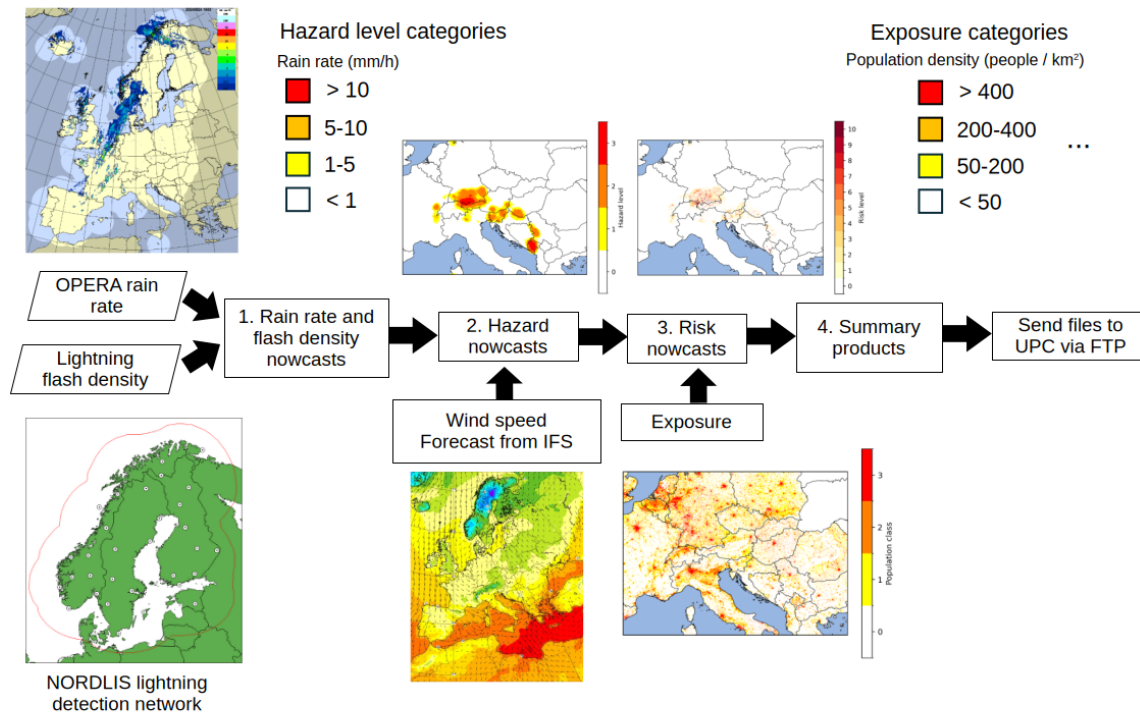


Figure 2. Overview of the storm impact product generation.

3 Nowcast methods

Precipitation nowcasts are produced by using OPERA rain rate composites and a convolutional neural network based on the Simpler yet Better Video Prediction (SimVP) architecture. The neural network has been implemented by using the Python-based PyTorch library (<https://pytorch.org>). It is combined with post-processing techniques to produce bias-corrected and probabilistic nowcasts. Probability information is currently not shown to users, but this is planned to be implemented in a future version.

While the main focus of the work has been on predicting precipitation, experimental products have been implemented for predicting lightning and wind hazard and risk. Lightning nowcasts are produced by simple extrapolation of flash density that is calculated in a 2 km grid by using lightning observations. The NORDLIS lightning detection network covering Scandinavia and the Baltic countries is used for this purpose. Pan-European coverage could be implemented in the future if requested by users.

The wind hazard and risk products use ECMWF's Integrated Forecasting System (IFS) high-resolution (HRES) forecasts at height of 10 meters above ground level. The forecasts are queried from the ECMWF product feed via the FMI SmartMet API every 12 hours. Horizontal and vertical

wind components are processed into wind speed (m/s) in the 2 km grid used with the other storm impact products.

4 Technical details

The storm impact products are generated in FMI. This is done using a set of scripts written in the Python programming language. A virtual machine with 16 AMD EPYC processors with each having two cores and 32 GB of system memory have been allocated for the purpose. With this configuration the product generation and uploading the files to UPC via FTP takes 5-6 minutes once started. Although the neural network for precipitation nowcasting has been trained by using a graphics processing unit (GPU), the nowcast models have been designed to run on a CPU only. This makes it easier to transfer the production to other computing environments, where a GPU might not be available.